2155

STOPPING WATER POLLUTION AT ITS SOURCE

MISA

Municipal/Industrial Strategy for Abatement

GLOBAL SEARCH FOR BAT OPTIONS APPLICABLE TO INORGANIC CHEMICAL SECTOR PLANTS

Ontario

Environment
Environnement

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GLOBAL SEARCH FOR BAT OPTIONS APPLICABLE TO INORGANIC CHEMICAL SECTOR PLANTS

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GLOBAL SEARCH FOR BAT OPTIONS APPLICABLE TO INORGANIC CHEMICAL SECTOR PLANTS

Report prepared for:

MISA Office
Ontario Ministry of the Environment

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OCTOBER 1992

PIBS 2155

MINISTRY NOTE

This report was produced as a reference document for the effluent limits development process for the Ontario Inorganic Chemical Sector (ICS).

The information presented will be used as a basis for setting effluent limits based on Best Available Technology for each of the Ontario ICS plants.

The report however may not be the sole basis on which limits for the ICS will be developed. Other sources of information, which are acceptable to the ICS Joint Technical Committee, may also be used in the limit setting process.

The views and ideas expressed in the report are those of the author and do not necessarily reflect the views and policies of the Ministry of the Environment, nor does mention of trade names or commercial products constitute endorsement or recommendation of their use.

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Section 1
INTRODUCTION

1.1 BACKGROUND

The Ontario Ministry of the Environment's (MOE) Municipal-Industrial Strategy for Abatement (MISA) program was initiated in 1986 to strengthen the controls on water pollution in the Province. The ultimate goal of the MISA program is the virtual elimination of persistent toxic contaminants from all discharges to Ontario's waterways.

The first phase of the MISA program involved the development of effluent monitoring regulations for nine direct discharging industrial sectors. These regulations require many direct dischargers to monitor flows and contaminants in their point source discharges. The second phase will involve the development of effluent limits regulations for each of the nine industrial sectors.

In order to develop effluent limits, pollution control technologies available to the industry for removal of contaminants must be evaluated. Furthermore, the financial and economic impacts of these technologies on the industry must be known. The best available technology (BAT) economically achievable (EA) for the industry can then be determined and will form the basis for setting effluent limits.

To this end, the MOE called for a two phase study to develop an inventory of BAT applicable to plants in the Ontario Inorganic Chemical Sector (ICS), as follows:

- **Global Study** - Development of an inventory of BAT applicable to the Ontario ICS plants, through a search carried out in Canada, U.S., Europe and elsewhere.

- **Ontario Study** - Evaluation of predicted performance and estimated costs of the recommended BAT options if installed at each Ontario ICS plant.

This report presents the results of the Global Study.

1.2 ONTARIO INORGANIC CHEMICAL SECTOR OVERVIEW

There are 27 plants in the Ontario ICS, ranging from small single product operations to large multi-products facilities. With few exceptions, each plant is unique in terms of size, products manufactured and wastewater generation and management. The following broad categories represent the range of plants included in the group:

- Industrial gas (6 plants)
- Abrasives (4 plants)

- Nitrogen fertilizers and nitrogen products (4 plants)
- Carbon black (2 plants)
- Phosphate products (2 plant)
- Soda ash (1 plant)
- Hydrofluoric acid and chlorofluorocarbons (1 plant)
- Aluminum chloride (1 plant)
- Chlor-alkali (1 plant)
- Mineral wool insulation (1 plant)
- Carbon and graphite electrodes (1 plant)
- Industrial liquid and gas packaging (2 plants)
- Explosives (1 plant).

Wastewater generated within the industry, by virtue of the products manufactured, contains a number of conventional and priority pollutants. Conventional pollutants found include suspended solids, acids, bases, chlorides, phosphorus, fluoride and nitrogen compounds. Priority pollutants include heavy metals as well as organic contaminants. Industry effluent flows range from less than 25 m^3/d to greater than 250,000 m^3/d.

Physical chemical treatment processes as well as in-plant water management measures are currently used in the Sector to reduce contaminant loadings to receiving waters. Currently, some plants do not provide treatment, while others provide varying levels of treatment. Since effluent quality varies widely between plants, so does the range of applicable treatment.

The majority of the ICS plants are located in two general regions of Ontario: the Niagara Peninsula and south western Ontario (Sarnia area). However, there are a few plants outside of these areas, in Sault Ste. Marie, North Bay, Cornwall and Elmira.

1.3 STUDY DESCRIPTION AND OBJECTIVES

The purpose of the Global study was to develop an inventory of Best Available Technologies (BAT) applicable to the control of wastewater (excluding stormwater) discharged directly to receiving waters from Ontario Inorganic Chemical Sector Plants. The information on each technology includes sufficient information on design, limitations, performance and costs to allow for prediction of the costs and performance if the technology were applied to selected ICS plants.

Specific study objectives were:

1. To identify, through a search of installations in Ontario, Canada, the U.S., Europe and elsewhere, technologies which could provide improvements in the effluent quality of the ICS plants towards MISA program objectives.

2. To provide relevant, selected information on installations identified in the search with in-plant wastewater controls, such as chemical substitution, alternative manufacturing processes, best management practices, water reuse and recycle, etc., and end-of-pipe treatment technologies.

3. To provide sufficient information on as-found design, performance and cost of recommended BAT options to allow projection and performance and estimation of cost of each option if implemented at the Ontario ICS plant.

4. To prepare a report of study methodologies and technology inventory, that can be used as a reference document for projecting cost and performance of implementing options at Ontario ICS plants.

1.4 CONTENTS OF REPORT

Section 2 of the report presents the methodologies used in the Global search for BAT, with reference to tables of information sources in Appendix A. Sections 3 through 6 present the inventory of technologies identified as potential components of BAT options applicable to Ontario ICS plants, as follows:

Section 3	-	Reports on global site visits to "sister" plants, with available details on those technologies being considered as BAT options are included in this Section.
Section 4	-	This Section contains reports on technologies applicable to controlling wastewater discharges from general processes such as cooling tower blowdown, boiler blowdown, water treatment, etc. which are not specifically product related, and are used at several plants in the Sector. Also included are reports on technologies, not found at "sister" plants, but were considered for removing specific contaminants from industrial wastewater. Technologies were selected for inclusion based on their demonstrated ability to remove the contaminants of concern from wastewater with similar characteristics.
Section 5	-	Reports on those technologies that were identified specifically for an Ontario plant, such as in-plant changes, recycle, etc. are included in this Section.

Section 2

STUDY METHODOLOGIES

Several information search techniques were used to ensure that a comprehensive approach was used in the identification and collection of information on BAT applicable to the Ontario Inorganic Chemical Sector. These techniques included:

- An extensive literature search.
- A search for "sister" plants in Canada, U.S., Europe and Asia.
- A review of specific technologies applicable to certain plants in Ontario.
- A review of general wastewater treatment technologies applicable to treatment of target contaminants in effluents.

Each of the following sections describe these approaches, with reference to the lists of information sources and telephone contacts in Appendix A.

2.1 LITERATURE SEARCH

One of the first study tasks undertaken was a literature search aimed at identifying "sister" plants reported in the literature, identifying wastewater management practices used at inorganic chemical manufacturing plants and also identifying demonstrated technologies for advanced treatment of chemicals in inorganic chemical plant effluents.

The main component of the literature search involved a search of computerized databases in the CANOLE^R system. Databases searched included:

1. **Engineering Index (EI) and Engineering Index Meetings (EIM) produced by Engineering Information Inc.** These databases include references to over 4,500 primary publications and papers from 2,000 technical conferences annually from over 45 countries in 25 languages, covering all aspects of engineering and related technology areas.

2. **ELIAS database produced by the Environment Canada Department Library.** Over 70,000 serials, monographs, conference proceedings and technical reports from more than 20 libraries participating in the Environment Canada Departmental Library network are contained in this database.

3. **The NTIS database, produced by the National Technical Information Service of the U.S. Department of Commerce.** This database contains over 1.4 million references to U.S. government reports, government sponsored translations, foreign language reports and U.S. government owned patents in a number of technical areas including environmental pollution and control, and engineering.

4. **The CA82 and CA87 databases, produced by the Chemical Abstracts Services of the American Chemical Society.** Over four million references to journals, patents, books, conference proceedings, theses, technical reports and government reports cover all aspects of chemistry and chemical engineering.

Appendix B presents a list of key words used in the searches.

Titles and abstracts produced in the searches were screened and only potential relevant papers and reports were obtained. Very few of the references obtained contained information that assisted in the identification of BAT, or provided information on the costs and/or performance of demonstrated BAT technologies. Those literature sources referenced in the study are included in Appendix A. The poor literature search results confirmed that very few wastewater management changes have been implemented and/or published in recent years, for most categories of inorganic chemical manufacturing. This was the general report from contacts in North America and Europe.

A number of other literature sources from CH2M HILL in-house libraries in Canada and the U.S. supplemented information retrieved in the literature search. These included government publications and textbooks, and reports and papers prepared by CH2M HILL staff. Referenced items used in the study are listed in Appendix A.

2.2 SISTER PLANTS

A search aimed at identifying BAT in use at inorganic chemical manufacturing plants in Canada, U.S. and other countries was undertaken to meet the study objectives. Specifically, the search focused on technologies applicable to Ontario ICS plants, because of their demonstrated use at "sister" facilities; those which are similar in size, products manufactured and complexity.

The search for "sister" plants covered:

- Ontario
- Canada, outside Ontario
- U.S.
- Europe
- Asia.

The literature search described in Section 2.1 was the first step in the "sister" plant search. Several other activities were undertaken as part of a comprehensive, thorough approach to a global review of sister plants. These are described in the following subsections.

2.2.1 SRI Directory Review

The SRI International Directories of Chemical Producers (1990) contain information on products and addresses of companies in four volumes: Canada, U.S., Europe and East Asia. Limited information on production capacity and type of manufacturing process is also presented. Although the directories only contain information for plants who are sponsors of the Directory of Chemical Producers Program, they are the most comprehensive source of information available. In addition, the Japan Chemical Directory (1987/1988) published by the Chemical Daily Co., Ltd. was reviewed.

For each of the directories examined, lists of all plants considered to be "sister" to Ontario plants were prepared. For the Canadian, U.S. and European directory review, these lists were used as an initial reference to industry plants to be investigated.

A short list of plants in Japan to be investigated was also developed. A contact at the Japan Technical Information Centre in Washington, D.C., was requested to provide information on these plants. Information was not received, and other means of obtaining information on these plants were not available within the time frame and scope of the study.

2.2.2 Canadian "Sister" Plant Search

Several approaches were utilized to identify "sister" plants potentially demonstrating U.S. BAT in Canada. These included:

- A request for information from Ontario Inorganic Chemical Sector plants on known Canadian "sister" plants.
- A request to Environment Canada for identification of well-operated inorganic chemical manufacturing plants across Canada.
- Follow-up with contacts provided through discussions with equipment suppliers, other plants, etc.
- The SRI Directory review, described in 2.2.1.
- A review of the literature, described in 2.1.

Each potential "sister" plant identified was contacted by telephone and information on the plant processes, wastewater management system, and effluent limits was requested. "Sister" plants that appeared to be demonstrating more advanced wastewater management technologies, or which were discharging better quality effluents or smaller contaminant loadings to receiving waters, compared to Ontario plants, were targeted for site visits. The telephone contact list in Appendix A includes Canadian plant contacts that were made.

Two site visits were made in Canada, to the following plants:

1. **PPG Canada Inc., Beauharnois, Quebec** - Formerly a mercury cell chlor-alkali plant, the plant had recently converted to a membrane cell technology operation. Also of interest was an acid sulphide precipitation system for mercury treatment, being used for site clean-up of the former mercury cell operation.

2. **Simplot Canada, Brandon, Manitoba** - Several wastewater management methods different from those in the Ontario operations are used at this plant. These include the use of nitrogen solutions as ion exchange column regenerants, evaporation of process effluents to produce saleable nitrogen solutions, various pollution prevention systems and the use of dilute nitrogen contaminated stormwater for fertigation.

In addition, Cabot Canada, a carbon black plant, was identified to be demonstrating BAT, and was considered as a "sister" for Columbian Chemicals. Both plants were visited as part of the Ontario Study.

A discussion of the site visit report format is presented in Section 2.2.4. Site visit reports are contained in Section 3.

2.2.3 "Sister" Plant Search in the U.S.

In order to ensure a comprehensive search for appropriate "sister" plants in the U.S. of interest to the study, several information collection activities were undertaken. These included:

- Telephone contact with industrial associations representing manufacturing plants included in the Ontario Inorganic Chemical sector.

- A meeting with the U.S. EPA representative who was responsible for the development of U.S. BAT regulations for the inorganic chemical manufacturing categories.

- A review of the SRI Directory of Chemical Producers.

- A review of NPDES permits for all plants identified.

- A request for information on U.S. "sister" plants from contacts at the Ontario plants.

- Follow-up contacts to equipment suppliers, etc.

Telephone contacts were made for all "sister" plants identified as potentially demonstrating U.S. BAT. Appendix A presents the contacts that were made in the U.S. "sister" plant search.

Three site visits were carried out as a result of the search. These included:

1. **Explosives Technology International in Seneca, Illinois** - This plant was identified as the only explosives plant in the U.S. with a similar product line to the Ontario plant. Several wastewater management practices exist at this plant different than those in Ontario.

2. **Allied South Works in Baton Rouge, Louisiana** - A similar line of chlorofluorocarbon products to the Ontario plant are produced at this plant. Of particular interest was a steam stripping process to remove volatile contaminants from effluents, and a calcium chloride recovery facility to recover chloride from waste hydrochloric acid scrubber effluents.

3. **Allied Signal Hydrofluoric Acid Plant in Geismar, Louisiana** - The Geismar plant was selected because it has a well operated hydrofluoric acid plant effluent treatment system which represents U.S. BAT.

The site visit reports are discussed in Section 2.2.4.

2.2.4 European "Sister" Plant Search

Several "sister" plants in Europe of potential interest to the study were identified using a number of approaches, including:

- A literature search

- A review of the SRI Directory of Chemical Producers in Europe

- A request for information on European "sister" plants from contacts at the Ontario plants

- Contact with various governmental and non-governmental environmental agencies in Europe, made by CH2M HILL's London, U.K. office.

From the above search, a list of several possible "sister" plants was developed. The assistance of the Ontario Ministry of Industry, Trade and Technology, and Department of External Affairs and International Trade Canada was requested to facilitate contacts with European plants. Both of these agencies have officers placed in several European countries. The Ontario Ministry could not offer any assistance to carry out the project. External Affairs participated by providing contact names, phone numbers and addresses for plants on the list.

CH2M HILL's London, U.K. office staff telephoned each of these plants to request information on their processes, wastewater management practices and effluent limit requirements, and to obtain permission for a site visit. A list of contacts is provided in Appendix A. Where plants were unwilling to provide information, the Ontario Ministry of the Environment and the Canadian Chemical Producers Association (CCPA) were asked to facilitate; whereby letters were sent to target companies explaining the purpose of the study. None of the companies contacted were willing to allow site visits, and only a few companies provided limited information on the plants of interest.

2.2.5 "Sister" Plant Site Visit Information Reports

For each plant visited during the study, site visit information reports were prepared. The purpose of the reports were to present background information on the facility with particular focus on the technologies that were considered BAT and potentially applicable to Ontario plants.

The information that was requested for each facility included:

- Plant name and location.
- Manufacturing processes description.
- Plant age/process technology age.
- Design capacity of manufacturing processes.
- Raw materials, major products and bi-products used or produced at the plant.
- Rates of water use, reuse and recycle.
- Wastewater flow rates for each individual production facility.
- Descriptions of in-plant treatment, including limited relevant technical design specifications and performance data.
- Influent (raw wastewater) and effluent quality, including toxicity data.

- Concentration range of pollutants in the raw wastewater that the technology is designed and shown capable of treating.

- Known limitations and applicability.

In addition, for technologies included in the recommended BAT options, the following information was requested:

- As-built capital and current operating costs.

- Energy requirements.

- Waste disposal costs, if any.

- Scale range of plant size over which the technology is applicable.

- Process details sufficient to allow for equipment re-sizing calculations and the estimation of present day cost of installation at other plants.

In most cases, due to concerns with respect to confidentiality or due to unavailability of data, all of this additional information was not provided.

All collected information was documented in a site report. Site reports for all plants visited in the study are included in Section 3 of this report.

2.3 TECHNOLOGY REPORTS

Technology reports were prepared to provide cost and performance information on technologies applicable to wastewater management of effluents from processes that were not unique to the manufacturing facility. Examples of these include cooling towers, boilers and water treatment. In this section, a report on pumps, pumping stations and forcemains was also included, since these systems are often required for BAT implementation. In addition, there were many categories of manufacturing in Ontario for which "sister" plant BAT were not identified. However, effluents from several of the Ontario plants contain contaminants that can be reduced by means of demonstrated technologies used in other sectors.

Technologies were identified through:

- Discussions with knowledgeable CH2M HILL staff in Canada and the U.S.

- A literature search.

- Discussions with industrial contacts, and water treatment chemical and equipment suppliers in Canada and the U.S.

These contacts, and CH2M HILL in-house information provided costs and performance that were presented in each report. The general technology reports are included in Section 4.

2.4 PLANT SPECIFIC TECHNOLOGY REPORTS

Information was provided by some of the Ontario Inorganic Chemical Sector plants on wastewater management technologies being considered for implementation at their plants, or specific to their particular plant. Where these technologies would improve effluent discharge quality, or reduce contaminant loadings, they were included in the inventory of BAT. Consequently, plant specific technology reports presenting a description of the technology, its capital and operating requirements and estimated performance were prepared. These reports are included in Section 5 of this report.

Section 3
SISTER PLANT GLOBAL SITE VISIT REPORTS

INORGANIC CHEMICAL SECTOR GLOBAL BAT STUDY
SISTER PLANT - GLOBAL SITE VISIT REPORT
SIMPLOT CANADA LIMITED

1.0 PLANT SITE

Simplot Canada Limited
P.O. Box 940
Brandon, Manitoba
R7A 6A1

Primary Contact:	Gordon Collis, P.Eng. Plant Administrator
Telephone: Fax:	(204) 729-2870 (204) 729-2886
Date of Visit:	July 19, 1991

2.0 PLANT DESCRIPTION

The Simplot Canada, Brandon, Manitoba plant is an integrated nitrogen fertilizer manufacturing facility with the active plant covering about 12 hectares of a 400 plus hectare site. The facility commenced production in June 1967. The plant has since had numerous expansions and incremental upgrades. At present, the facility consists of two ammonia synthesis plants, a nitric acid plant, an ammonium nitrate prill plant, two urea prill plants, a nitrogen solutions plant, and plants for manufacturing ammonium phosphate and ammonium thiosulphate solutions. At the present time, the facility can produce approximately 270 tonnes of ammonia or equivalent nitrogen content products per day. The facility operates continuously. Current employment is about 230 with part-time supplements in the spring and fall for shipping product.

Figure A1 of the Appendix presents a plant schematic which shows inputs, recycle and recovery systems, plant emissions, and products. A brief description of each process follows.

3.0 PROCESS DESCRIPTIONS

Anhydrous Ammonia (Two Plants)

Natural gas is reformed along with steam and oxygen from an air separation plant in the presence of catalysts to obtain hydrogen. This gas is reacted with nitrogen over another catalyst at high pressure to produce ammonia. The ammonia produced is liquified and stored at atmospheric pressure in an 18,000 tonne insulated storage vessel. Carbon dioxide by-product from hydrogen products is recovered using monoethanolamine stripping and is utilized onsite in the manufacture of urea. Surplus carbon dioxide is sold to a Liquid Carbonic purification facility located adjacent to the plant site.

Nitric Acid

Ammonia is oxidized over a platinum catalyst to produce nitrogen oxides. The oxides, with air, are absorbed in water in an absorption tower yielding nitric acid.

Ammonium Nitrate

Ammonia and nitric acid are reacted to form ammonium nitrate solution. The ammonium nitrate solution is stored for making nitrogen solution products or it is concentrated and sprayed through a counter current air flow in the prill tower to form spherical prills. The prills are cooled, coated with anticaking agents and then transported by belt conveyor to bulk storage/sales.

Urea

Carbon dioxide recovered from the hydrogen production and from liquid ammonia are reacted at high pressure to form urea. This concentrated urea liquid is used to make nitrogen solution or is concentrated and granulated in a rotary drum granulator.

Nitrogen Solutions

Urea and ammonium nitrate solutions are combined to form 28-0-0[1] liquid nitrogen fertilizers, that are pumped to liquid storage tanks. Up to 1,400 tonnes per day are produced during peak season.

Liquid Ammonium Polyphosphate

Ammonia and imported polyphosphoric acid are combined in a pipe reactor to form a concentrated solution of ammonium polyphosphate fertilizer. This fertilizer has characteristics 10-34-0[2]. During peak periods, it is produced at a rate of 700 tonnes per day is produced during peak consumption.

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[1] 28 percent nitrogen.

Ammonium Thiosulphate

Molten sulphur is burned in air in a furnace to produce sulphur dioxide. Sulphur dioxide and ammonia are absorbed in water to form ammonia sulphite in an absorption tower. This ammonium sulphate solution is then reacted with additional molten sulphur to yield an ammonium thiosulphate solution (12-0-0-26).

4.0 WASTEWATER MANAGEMENT

4.1 Permit Requirements

Simplot Canada utilizes a wastewater management approach to meet the terms of their Manitoba Provincial Wastewater Discharge License No. 1273. Wastewater which is not reused in product or for "fertigation" flows to an outfall in the Assiniboine River about 2.5 km from the plant, through a system of pipes and natural drainage ditches. The permit allows the discharge of wastewater meeting certain loading limitations during the period of September 15 through May 15 each year. During the May 15 to September 15 period each year, the facility may not discharge wastewater. Fertigation ponds provide additional storage for effluent during this plant.

The permit limitations during discharge are:

• Total nitrogen	204 kg/d
• Ammonia nitrogen	91 kg/d
• Phosphorus	20 kg/d
• Sulphate	2,722 kg/d
• Residual chlorine	1.4 kg/d
• pH	6.0-9.0

Ponds had a much greater capacity. The total plant sewer monitoring station, which is located at the plant fence, is equipped with continuous pH, ammonia nitrogen, nitrate nitrogen monitors and alarms. If wastewater quality exceeding permit levels is detected, it is diverted to fertigation ponds. This effluent water is used for "fertigation" (this allows the facility to operate without wastewater discharge to the river during the period of May 15 to September 15 each year).

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[2] 10 percent nitrogen, 34 percent phosphate.

4.2 Effluent Fertigation

"Fertigation" is the spray irrigation of land with the nitrogen containing wastewater. Simplot has used this disposal technique on up to 1,090 hectares of land in close proximity to the plant. In general, this land is rather poor for agricultural purposes with its primary use being the production of forage for grazing animals.

Simplot's permit allows the application of a maximum of 224 kg of nitrogen per hectare only during the period April 19 to October 15 each year. Current practice is to apply about 134 kg per hectare. Each field that is used is sampled in ten locations at depths of 0.3, 0.61, and 1.22 meters for total nitrogen to monitor for possible groundwater problems due to migration (Each field is limited to 32.4 hectares).

At the present time, Simplot has made many small process changes to the wastes that are sent to its concentrated waste pond that this ponded water has reached concentration levels that will allow the sale of this wastewater as fertilizer. As a result of not needing to use concentrated waste in fertigation, the land use has been reduced to about 405 hectares. The fertigation project uses land owned by private farmers, and fertigation service is provided at no cost to the farmer.

5.0 IN-PLANT WASTE RECOVERY AND MINIMIZATION

Simplot has managed to meet its permit limits on ammonia nitrogen by avoiding the discharge of contaminated wastewater. Figure A2 of the Appendix presents a flow diagram that identifies the plant wastewater recovery system.

5.1 Boiler Water Preparation

The well water used to supply the site is particularly high in sulphate (270 to 500 mg/L).

The utilities plant uses two ion exchange systems in parallel to treat water for use in steam generation. Simplot uses ammonium hydroxide and nitric acid produced on site to regenerate the ion exchange resin. The effluent solutions from are regeneration are placed in a lined pond of 45,400 m^3 capacity. At present, this pond receives primarily this regeneration effluent stream, although if high concentration wastes are collected with first-flush stormwater or by spill cleanup, they would also go to this pond. At present, the pond has reached a nitrogen level of 2 percent and Simplot can sell this material at this concentration.

A 2 percent concentration in the pond was achieved by installing automatic conductivity controls on the regenerate cycle so that clean water can be automatically routed for use as cooling tower feed, thus avoiding dilution of the pond.

5.2 Feed Water for the Solutions Plant

Feed water for the solutions plant comes from a number of wastewater sources throughout the facility as indicated below.

1. Clean water from NH_3 plant oil separator.
2. Well water from groundwater nitrogen control wells. A previous tank rapture led to loss over 1,000 t of nitrogen. Thus, groundwater pumping is being utilized to prevent spread of contamination.
3. Wastewater from all washdown in urea plant.
4. Scrubber water from urea plant granulator scrubber.
5. Ammonium nitrate contaminated condensate when partial recycle urea unit is down (this stream normally goes to partial recycle urea plant).

5.3 Total Recycle Urea Plant Stripper

Simplot has recently added a steam stripper to remove NH_3 on the condensate from the total recycle urea plant. The stripped water is now routed to the utilities area for reuse as boiler feed.

5.4 Stormwater Management

All stormwater from the active site is collected in two ponds adjacent to the final total plant effluent monitoring station. The first of these ponds contains the initial volume of stormwater runoff from the start of a rain event referred to as "first flush". If runoff continues, it overflows at the entry point to a second, larger pond. These ponds are lined with approximately 1 meter of local clay. The collected water is sampled and can be trucked to the 2-0-0 pond if the concentration is high. It can also be diverted to fertigation ponds or it can be discharged to the river if it is within the permit limits.

A number of collection sumps are located at points in the plant where contaminated water can be collected and hauled to the 2-0-0 pond. The solutions shipping area, the building roof, and immediate surroundings of the urea plant is also equipped with these sumps.

Simplot has also regraded the area surrounding the plant fence so that runoff from these areas does not enter the plant collection system.

5.5 Projects Currently Underway

A number of new projects are underway that will enhance in-plant recovery and minimization of effluent discharges. These include:

1. A scrubber is being installed on the ammonium nitrate prilling tower to cut down losses in air. The scrubber water blowdown will be routed to the solutions plant.

2. A small evaporator plant will use vent steam from condensate recovery systems to evaporate the 2-0-0 pond water to 6 percent to 10 percent nitrogen. The evaporator design was done by plant engineers, and a total capital cost of $120,000 to $150,000 is anticipated.

5.6 Future Plans

Simplot is evaluating a proposal to replace the two existing ammonia plants with a state-of-the-art 820 tonne per day unit.

6.0 OBSERVATIONS

This facility illustrates the effectiveness of in-plant control and management as a means of attaining a reasonable level of discharge nitrogen control. The use of the fertigation holding ponds to avoid discharge of out-of-specification wastewater is necessary to make the system work. But the use of this methods depends on the climatic dryness of the area and free donation of irrigation water.

Simplot believes that the cooling tower blowdown, which represents 70 percent to 80 percent of the yearly effluent flow, is a primary source of ammonia in this discharge. This is a result of scrubbing fugitive ammonia emissions from the air.

7.0 AUDIT TEAM

Dr. A (Tony) Edmonds: Project Officer, MISA Office
Ms. Deborah Ross: CH2M HILL
Mr. Leo C. Ehrenreich: SAIC

APPENDIX

Figures

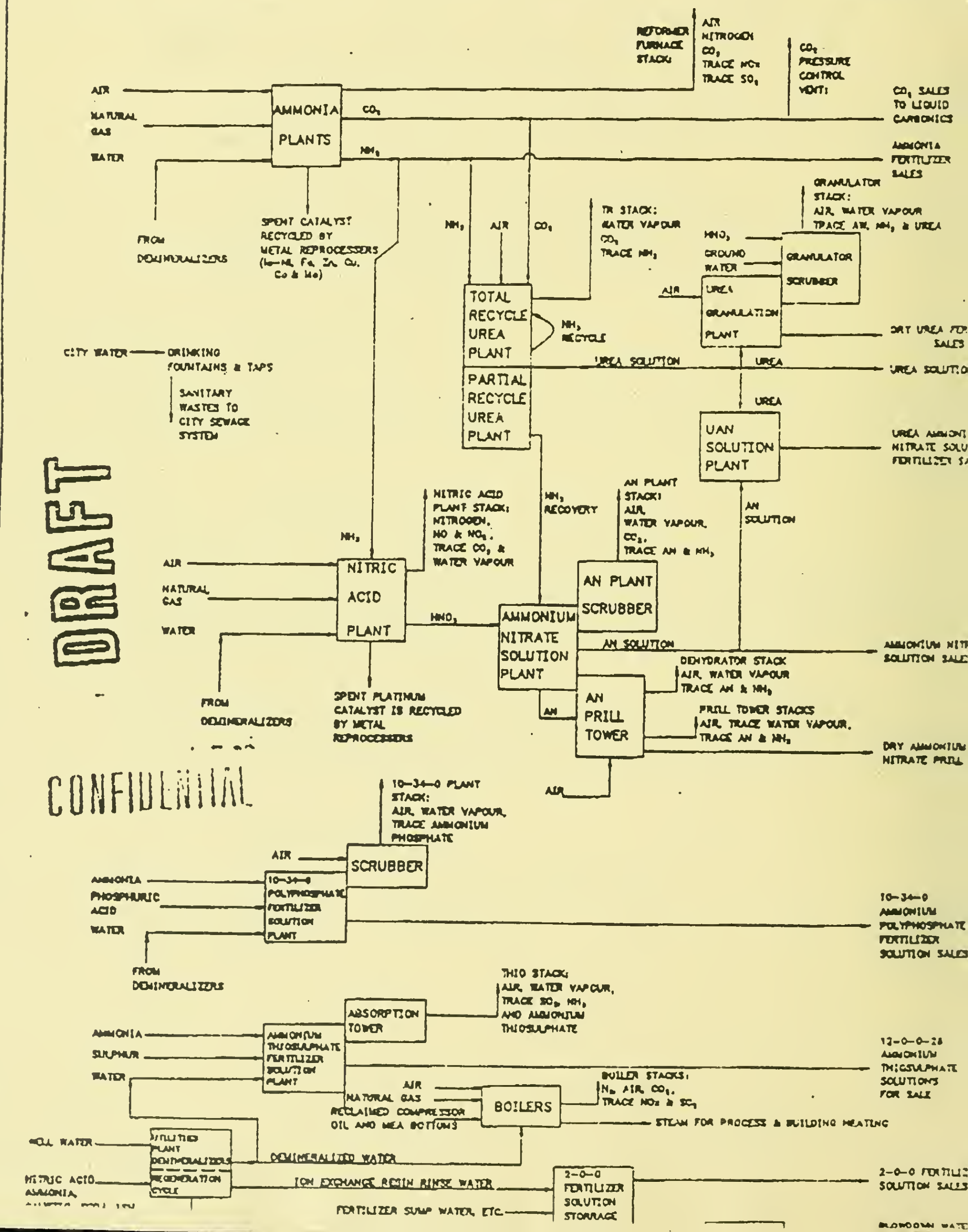
Figure A-1

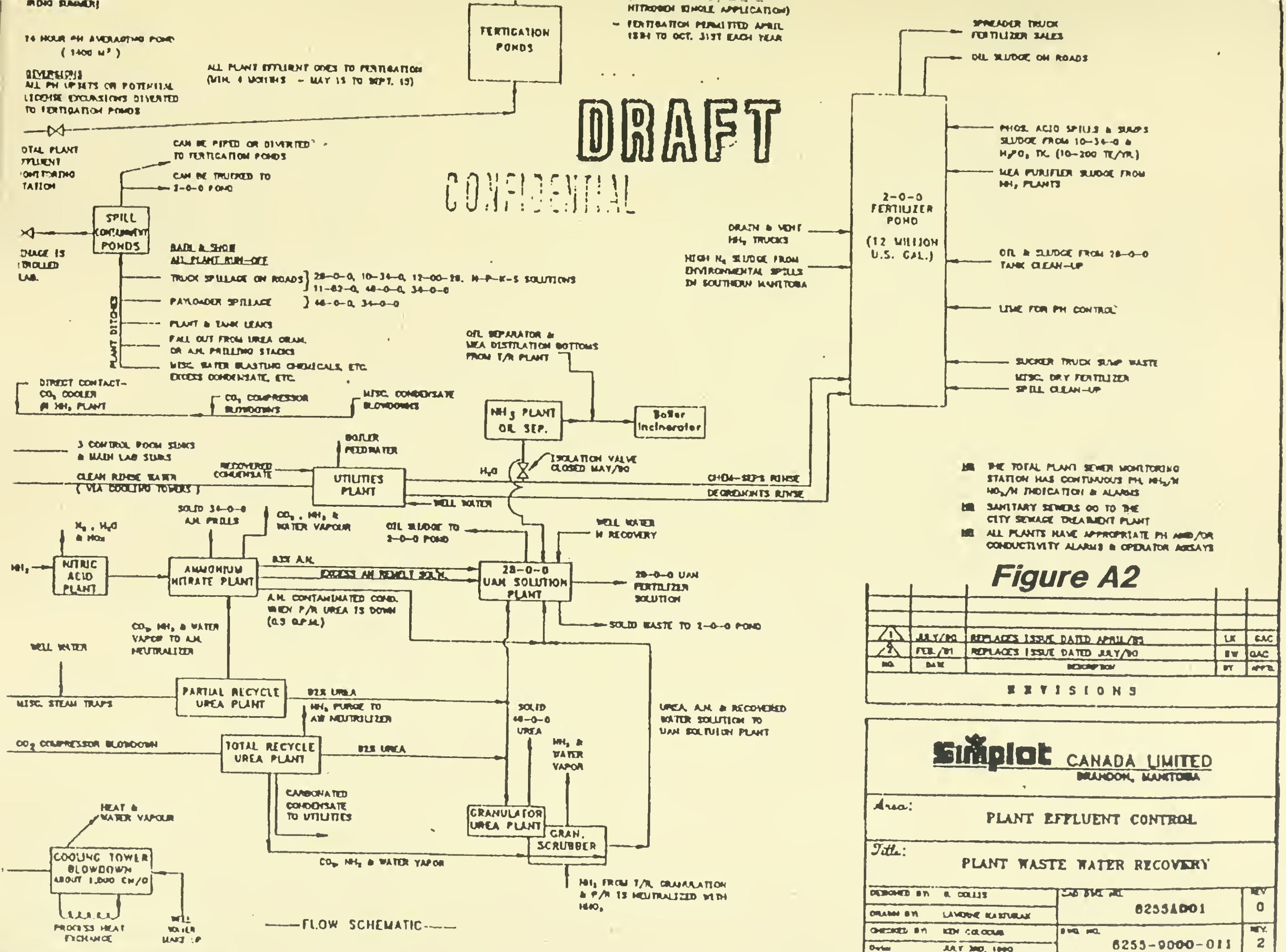
Simplot CANADA LIMITED
BRANDON, MANITOBA

SUBJECT: [illegible]

BY: HARRY WILLIAMSON DATE: MARCH 22, 1991 SHEET NO. 1 OF 1

A.M.E. NO. [illegible] DWG. NO. [illegible]
CAD NO. 8254A003


REFORMER FURNACE STACK:
AIR
NITROGEN
CO_2
TRACE NO_x
TRACE SO_2
CO_2 PRESSURE CONTROL VENT:
AIR
NATURAL GAS
WATER
AMMONIA PLANTS
CO_2
NH_3
CO_2 SALES TO LIQUID CARBONICS
AMMONIA FERTILIZER SALES
FROM DEMINERALIZERS
SPENT CATALYST RECYCLED BY METAL REPROCESSERS (Ni-Mo, Fe, Zn, Cu, Co & Mo)
NH_3
AIR
CO_2
TR STACK: WATER VAPOUR CO_2 TRACE NH_3
GRANULATOR STACK: AIR, WATER VAPOUR TRACE AN, NH_3 & UREA
HNO_3
GROUND WATER
GRANULATOR SCRUBBER
AIR
UREA GRANULATION PLANT
TOTAL RECYCLE UREA PLANT
NH_3 RECYCLE
DRY UREA FER SALES
UREA SOLUTION
UREA
UREA SOLUTIO
CITY WATER
DRINKING FOUNTAINS & TAPS
SANITARY WASTES TO CITY SEWAGE SYSTEM
PARTIAL RECYCLE UREA PLANT
UREA
UAN SOLUTION PLANT
UREA AMMONI NITRATE SOLU FERTILIZER SA
DRAFT
NITRIC ACID PLANT STACK: NITROGEN, NO & NO_2, TRACE CO_2 & WATER VAPOUR
NH_3 RECOVERY
AN PLANT STACK: AIR, WATER VAPOUR, CO_2, TRACE AN & NH_3
AN SOLUTION
NH_3
AIR
NATURAL GAS
WATER
NITRIC ACID PLANT
HNO_3
AN PLANT SCRUBBER
AMMONIUM NITRATE SOLUTION PLANT
AN SOLUTION
AMMONIUM NITR SOLUTION SALE
DEHYDRATOR STACK AIR, WATER VAPOUR TRACE AN & NH_3
FROM DEMINERALIZERS
SPENT PLATINUM CATALYST IS RECYCLED BY METAL REPROCESSERS
AN
AN PRILL TOWER
PRILL TOWER STACKS AIR, TRACE WATER VAPOUR, TRACE AN & NH_3
DRY AMMONIUM NITRATE PRILL
AIR
CONFIDENTIAL
10-34-0 PLANT STACK: AIR, WATER VAPOUR, TRACE AMMONIUM PHOSPHATE
AIR
SCRUBBER
AMMONIA
PHOSPHORIC ACID
WATER
10-34-0 POLYPHOSPHATE FERTILIZER SOLUTION PLANT
10-34-0 AMMONIUM POLYPHOSPHATE FERTILIZER SOLUTION SALES
FROM DEMINERALIZERS
THIO STACK: AIR, WATER VAPOUR, TRACE SO_2, NH_3 AND AMMONIUM THIOSULPHATE
ABSORPTION TOWER
AMMONIA
SULPHUR
WATER
AMMONIUM THIOSULPHATE FERTILIZER SOLUTION PLANT
12-0-0-26 AMMONIUM THIOSULPHATE SOLUTIONS FOR SALE
AIR
NATURAL GAS
RECLAIMED COMPRESSOR OIL AND MEA BOTTOMS
BOILERS
BOILER STACKS: N_2, AIR, CO_2, TRACE NO_x & SO_2
STEAM FOR PROCESS & BUILDING HEATING
WELL WATER
UTILITIES PLANT DEMINERALIZERS
DEMINERALIZED WATER
NITRIC ACID AMMONIA
REGENERATION CYCLE
ION EXCHANGE RESIN RINSE WATER
FERTILIZER SUMP WATER, ETC.
2-0-0 FERTILIZER SOLUTION STORAGE
2-0-0 FERTILIZ SOLUTION SALES
BLOWDOWN WATE


DRAFT
CONFIDENTIAL
24 HOUR PH AVERAGING POND (1400 M³)
DIVERSIONS
ALL PH UPSETS OR POTENTIAL LICENSE EXCURSIONS DIVERTED TO FERTIGATION PONDS
ALL PLANT EFFLUENT GOES TO FERTIGATION (MIN. 4 MONTHS - MAY 15 TO SEPT. 15)
FERTIGATION PONDS
NITROGEN SINGLE APPLICATION)
- FERTIGATION PERMITTED APRIL 15TH TO OCT. 31ST EACH YEAR
OTAL PLANT FFLUENT ONITORING TATION
CAN BE PIPED OR DIVERTED TO FERTIGATION PONDS
CAN BE TRUCKED TO 2-0-0 POND
SPILL CONTAINMENT PONDS
DUAGE IS TROLLED LAB.
RAIN & SNOW
ALL PLANT RUN-OFF
TRUCK SPILLAGE ON ROADS
28-0-0, 10-34-0, 12-00-20, N-P-K-S SOLUTIONS 11-52-0, 46-0-0, 34-0-0
PAYLOADER SPILLAGE
46-0-0, 34-0-0
PLANT DITCHES
PLANT & TANK LEAKS
FALL OUT FROM UREA GRAN. OR A.N. PRILLING STACKS
MISC. WATER BLASTING CHEMICALS, ETC. EXCESS CONDENSATE, ETC.
DIRECT CONTACT- CO₂ COOLER @ NH₃ PLANT
CO₂ COMPRESSOR BLOWDOWNS
MISC. CONDENSATE BLOWDOWNS
3 CONTROL ROOM SINKS & MAIN LAB SINKS
CLEAN RINSE WATER (VIA COOLING TOWERS)
RECOVERED CONDENSATE
BOILER FEEDWATER
UTILITIES PLANT
WELL WATER
OIL SEPARATOR & MEA DISTILLATION BOTTOMS FROM T/R PLANT
NH₃ PLANT OIL SEP.
Boiler Incinerator
H₂O
ISOLATION VALVE CLOSED MAY/90
CHEM-SEPS RINSE
DEGREASANTS RINSE
NH₃
NITRIC ACID PLANT
N₂, H₂O & NOx
AMMONIUM NITRATE PLANT
SOLID 34-0-0 A.N. PRILLS
CO₂, NH₃ & WATER VAPOUR
83% A.N.
EXCESS AN REMELT SOL'N.
A.N. CONTAMINATED COND. WHEN P/R UREA IS DOWN (0.5 G.P.M.)
OIL SLUDGE TO 2-0-0 POND
WELL WATER N RECOVERY
28-0-0 UAN SOLUTION PLANT
28-0-0 UAN FERTILIZER SOLUTION
SOLID WASTE TO 2-0-0 POND
CO₂, NH₃ & WATER VAPOR TO A.N. NEUTRALIZER
WELL WATER
MISC. STEAM TRAPS
PARTIAL RECYCLE UREA PLANT
82% UREA
NH₃ PURGE TO AN NEUTRALIZER
CO₂ COMPRESSOR BLOWDOWN
TOTAL RECYCLE UREA PLANT
82% UREA
SOLID 46-0-0 UREA
NH₃ & WATER VAPOR
UREA, A.N. & RECOVERED WATER SOLUTION TO UAN SOLUTION PLANT
CARBONATED CONDENSATE TO UTILITIES
GRANULATOR UREA PLANT
GRAN. SCRUBBER
CO₂, NH₃ & WATER VAPOR
NH₃ FROM T/R GRANULATION & P/R IS NEUTRALIZED WITH HNO₃
HEAT & WATER VAPOUR
COOLING TOWER BLOWDOWN ABOUT 1,000 CM/D
PROCESS HEAT EXCHANGE
WELL WATER MAKE UP
2-0-0 FERTILIZER POND (12 MILLION U.S. GAL.)
DRAIN & VENT NH₃ TRUCKS
HIGH N₂ SLUDGE FROM ENVIRONMENTAL SPILLS IN SOUTHERN MANITOBA
SPREADER TRUCK FERTILIZER SALES
OIL SLUDGE ON ROADS
PHOS. ACID SPILLS & SUMPS SLUDGE FROM 10-34-0 & H₃PO₄ TK. (10-200 TE/YR.)
MEA PURIFIER SLUDGE FROM NH₃ PLANTS
OIL & SLUDGE FROM 28-0-0 TANK CLEAN-UP
LIME FOR PH CONTROL
SUCKER TRUCK SUMP WASTE
MISC. DRY FERTILIZER SPILL CLEAN-UP
—FLOW SCHEMATIC—

NB THE TOTAL PLANT SEWER MONITORING STATION HAS CONTINUOUS PH, NH_3/N NO_3/N INDICATION & ALARMS

NB SANITARY SEWERS GO TO THE CITY SEWAGE TREATMENT PLANT

NB ALL PLANTS HAVE APPROPRIATE PH AND/OR CONDUCTIVITY ALARMS & OPERATOR ASSAYS

Figure A2

NO.	DATE	DESCRIPTION	BY	APP'D.
1	JULY/90	REPLACES ISSUE DATED APRIL/89	LK	GAC
2	FEB./91	REPLACES ISSUE DATED JULY/90	BW	GAC

REVISIONS

Simplot CANADA LIMITED
BRANDON, MANITOBA

Area: PLANT EFFLUENT CONTROL

Title: PLANT WASTE WATER RECOVERY

DESIGNED BY	R. COLLIS	CAD DWG. NO. 8255A001	REV 0
DRAWN BY	LAVERNE KASTUR[illegible]		
CHECKED BY	KEN COLCOUGH	DWG. NO. 8255-9000-011	REV. 2
DATE	JULY 3RD, 1990		

INORGANIC CHEMICAL SECTOR GLOBAL BAT STUDY
SISTER PLANT - GLOBAL SITE VISIT REPORT
PPG CANADA INC.

1.0 PLANT SITE

PPG Canada, Inc.
Produits Chimiques Industriels
C.P. 2010
Beauharnois, Quebec
J6N 3C3

Telephone: (514) 429-4641

The site visit was arranged with the co-operation of:

Mr. William Graybill
Director of Environmental Affairs
PPG Chemicals
Pittsburgh, PA

Telephone: (412) 434-3131

Mr. Oscar Zamora
Plant Manager
PPG Canada
Beauharnois, Quebec

Technical Contacts:

Mr. Michael (Mike) Wolanyk
Operations Manager
Beauharnois Plant

Mr. Donald Cowan
Technical Director
Beauharnois Plant

Mr. Yves Denicourt
Environmental Engineering
Beauharnois Plant

2.0 PLANT DESCRIPTION

The PPG Canada facility is located in an industrial area just west of Beauharnois, Quebec. It is separated from the south shore of Lac Saint Louis by a highway and another industrial facility. Just west of the plant is the Hydro Quebec Beauharnois Hydroelectric Station. The site was originally opened by Dominion Tar and Alkali (now DOMTAR) in 1949 with mercury cells of a Krebs design.

In 1955 the facility was acquired by PPG. In March of 1971 the initial unit was shut down and a new Uhde design mercury cell unit with slightly higher capacity was started up the same day.

The mercury cell unit was shut down permanently on October 28, 1990 to allow the movement and incorporation of certain equipment in a new membrane chlor-alkali unit based on ICI technology utilizing DuPont fluoropolymer membranes. The new unit, energized on December 18, 1990, is of monopolar design, and is rated at 200 ECU (electrochemical units) or about 75,000 tonnes per year of chlorine reported by the plant.

The plant has also manufactured sodium chlorate since 1959. In 1965 the sodium chlorate capacity was increased. In 1981 a new sodium chlorate unit designed by Chemetics was added. The original unit was shut down in 1985, and the building has been utilized to house the new membrane cell chlor-alkali unit.

3.0 PROCESS DESCRIPTION

3.1 Membrane Technology

This plant was converted from a mercury cell chlor-alkali process to a membrane cell chlor-alkali plant in 1990. From a wastewater perspective this will result in the elimination of mercury from the plant discharge when the decontamination of the old plant and the surrounding site is completed. The Uhde cell plant which was replaced, had been in operation since 1971 and had reached an age where it was becoming difficult to maintain economic operation.

The overall economics are described by PPG personnel as strongly in favour of membrane plant technology for a refurbished facility. The elimination of environmental and safety costs associated with mercury control are among the positives. The decision to replace the mercury cell plant with the membrane plant was not taken for mercury control reasons, rather it was the overall economics at the site.

The factors that favor membrane technology include:

- Energy saving, due to an advantage in initial polarization; mercury cells, 3.2 volts; membrane cells, 2.4 volts. In addition, over the life of the cell, the membrane cell can exhibit a higher current efficiency. The mercury cell exhibits a current efficiency of about 94 percent. The membrane cell starts out higher but deteriorates as the membrane is fouled (function of brine purity).

- Estimated 20 percent savings in labour. This is primarily in cell room labour associated with maintenance and reconditioning of cells which is expected to be reduced by 75 percent.

- Elimination of hazardous landfill cost.

- Elimination of mercury monitoring of air, water, and personnel.

- Eventual elimination of operating cost of mercury treatment facilities.

- Elimination of liquid leaks associated with cell room operation since system is gas tight and operable without the liquid seals required for mercury cells.

- The process is more efficient in that complete chlorine recovery in the liquefaction plant is possible because there is no air entrainment. In mercury cells, because the system is run under negative pressure to prevent mercury loss, air is present in chlorine collected.

The conversion at Beauharnois made use of much of the equipment from the mercury cell plant. This resulted in the facility being out of production for a period of only about two months. The project was made more economic in that it utilized the old chlorate plant building, the old rectifiers and transformers, the salt storage and the original brine preparation equipment, and the existing liquification facilities. The cost of the project, was reported to be about $40,000,000 (1990).

The economic operation of a membrane plant depends heavily on brine. Selected salt sources are used since some impurities are difficult to remove.

Purifaction utilizes precipitation, clarification, and ion exchange as integral parts of the operation. Depleted brine is mostly resaturated and recycled to the cells, and only a small bleed stream is removed to avoid build up of persistent impurities.

The target life for the membrane is about three years. The wastewater discharge from a membrane plant will normally include non-contact cooling water and some discharge from the brine treatment train and ion exchange unit.

Overall, wastewater quality is similar for a mercury cell and membrane cell facility with the exception that mercury is not present in the membrane plant discharge.

3.2 Plant Decontamination

The decision to decommission the mercury cell allowed consideration of decontamination of the site. PPG's approach was to restore the site so that it may become mercury free and continuing mercury monitoring would not be required. At Beauharnois, this included the decontamination of the mercury cell sites. All equipment contaminated with mercury is to be cleaned up and eventually landfilled, and the building will be demolished and the rubble landfilled. The site was also known to have some subsurface mercury contamination so a plan was developed to decontaminate or place soil in a secure landfill.

In 1988 a project to characterize the site and develop a restoration plan was undertaken. A plan was submitted to the Province of Quebec and approval received. In 1989 permission was granted to build a secure landfill on PPG property about 0.5 km from the plant. The landfill will use a double membrane approach with a leachate collection system under each layer. The decontamination procedure includes cleaning up the old mercury cells and treating the mercury bearing wastewater in the treatment plant. In addition, PPG estimates that about 150,000 m^3 of soil will be removed and tested for mercury. The site characterization revealed contamination penetrated as much as about 8 meters at some points. As the project proceeds, a soil washing plant will be used to clean up highly contaminated soil. The treatment method is under patent review so PPG would not discuss the process details.

The final step in restoration will be to dismantle the sulphide precipitation treatment plant and demolish and remove that building.

The criteria being used for how materials removed are handled as follows:

1. Any waste with mercury levels less than 8 mg/L can go to an industrial landfill (Province of Quebec limit is 10 mg/L).

2. Any waste with mercury levels greater than 8 but less than 50 mg/L will go to the secure lined landfill.

3. Any waste sampled at greater than 50 mg/L or if mercury metal is visible (even if tested below 50 mg/L), it will be treated until it can be landfilled.

The site restoration project is expected to be completed in 1993 at a total cost estimated at $30,000,000. This cost would be incurred even if PPG ceased manufacturing at the site.

4.0 WASTEWATER TREATMENT

4.1 Treatment History

- Began recycling contaminated streams in 1969.

- Built alkaline sulphide precipitation plant in 1972 with about 30 m^3/d capacity.
- Expanded several times during 1970 as more contaminated streams were treated.
- 1983-1984 put in groundwater collection system to treat contaminated groundwater.
- 1983-1984 made decision to build new mercury treatment system based on precipitation under acid conditions.

4.2 Alkaline Sulphide Precipitation System

Although this system has been shut down since 1984, some comments on its operation were offered as follows:

- The system used an activated carbon bed to remove excess chlorine prior to the addition of the sodium hydrosulphide (NaSH).
- The filtration was performed using a precoated pressure leaf filter. The filter bed was found to be prone to pinholing and, therefore bypassing.
- It was observed that if the pH was high, the process would form "polysulphides", which are much more soluble than mercuric sulphide (HgS) and resulted in high levels of mercury in the effluent. The formation of polysulphides appeared to continue for some time even after the pH was returned to the correct range.
- The facility used an activated carbon treatment for final mercury polishing. About 25 percent of the time, it appeared to be adding mercury to the stream. At other times it appear to have no effect or to provide insignificant removal. PPG facilities in the United States that use a long residence period pond for sedimentation report good results with carbon treatment. It was not known if sulphur treated carbon was used in the United States. The material which was used at Beauharnois was not sulphur treated.
- The overall impression from the plant is that alkaline sulphide precipitation plant are difficult to operate to maintain consistently low mercury levels.

4.3 Acidic Sulphide Precipitation System

Since 1984-1985, this facility has utilized sulphide precipitation process operating under acidic conditions (pH 4 to 5). The design has been adapted from process developed at the

Oxychem plant in Deerpark, Texas. The plant reported a total implementation costs for the new treatment plant of $4.5 million (1985).

The main reason for selecting acid sulphide precipitation process were:

1. Soluble polysulphides would not be formed, thus, increasing the mercury removal performance.

2. Sulphides of other metals are less likely to precipitate under acidic conditions.

3. Control of residence times gives a more easily filtered precipitate.

The PPG plant is still being operated to treat contaminated groundwater and surface runoff as well as wastewater from the decontamination work on the plant. These stormwater and groundwater systems were designed to manage either a 25-year, 24-hour maximum storm event as well as the 25-year, maximum one-month precipitation event. These systems provide capacity to handle these storm flows but constant attention to reducing collected wastewater is required to manage these systems.

The treatment plant actually receives wastewater from three collection systems. The first handles process wastes from the old mercury cell room area. A second system, referred to as the Woodward-Clyde trenches, intercepts and collects any contaminated subsurface water. A third system collects stormwater runoff from building and other areas of the plant which have been found to be contaminated.

The first system discharges to a tank with approximately 380 m^3 capacity, located outside treatment plant. The tank is operated at about one third capacity, to provide an additional buffer to handle recycle if there are problems in treatment. The tank is agitated by pumping and recycling. This provides about 20 hours of equalization for the treatment plant feed during regular operations. The water collected in the latter two systems is pumped to a second tank with about a 280 m^3 capacity, also located adjacent to the treatment plant building.

The treatment plant has a nominal design capacity of about 680 m^3/d, with maximum pumping capacity designed for 950 m^3/d. When the mercury cell unit was operating, the treatment plant was handling 520 to 570 m^3/d. At present, the plant treats about 270 to 330 m^3/d.

Figure A1 in the Appendix presents a flow diagram of the process. The treatment plant consists of four agitated tank reactors operating in series. The water leaving the fourth reactor goes to a mix tank where diatomaceous filter acid earth is added continuously. The solids are removed in a plate and frame filter press.

In the first reactor with a nominal five minute residence time at design rates, NaSH is added and excess chemical reducing power is detected by an electrochemical sensor probe on the discharge. The wastewater pH is continuously monitored as it enters the second reactor where sulphuric acid from the chlorine drying process is added to bring the pH to the 4 to

5 range. The second reactor also has a nominal five-minute residence time. The third reactor has a 15-minute residence time and pH monitoring on the discharge so that the pH can be maintained in this tank in the 4 to 5 range by the addition of more acid.

The fourth reactor has a residence time of about 45 minutes and has a provision to add additional NaSH to maintain an effluent concentration of about 0.5 mg/L sulphide. The sulphide level is measured indirectly by an electrochemical sensor probe.

The pH and electrochemical sensor probes and the reagent feed mechanism are connected in an interactive control loop which is constantly modifying its reagent addition algorithm to reflect the mercury concentrations in the effluent, as monitored by a continuous mercury analyzer.

Effluent from the forth tank mixed with diatomaceous earth is passed through one of two filter presses. These are operated alternately so that one can be cleaned and precoated to be ready for use while the other is on-line. The filter presses were cleaned on a three or four day schedule when the mercury cell plant was in operation. Under current operating conditions, the presses only need cleaning approximately once per week. At the present time, about 50 percent of the filtrate is being recycled to maintain adequatic pressure on the filter (i.e. recycle is made necessary by the reduced inflow since the mercury cells stopped operating).

The filtrate is monitored in-line for mercury utilizing two analyzers developed by PPG. The analyzers take a discrete sample and utilize analytical technique based on the standard method for mercury analysis utilizing DuPont 400 detector systems. Each analysis takes about four minutes to complete. The two analyzers are set up to alternate so a sample is taken every two minutes. The operator periodically compares the two analyzers. If the results differ, analyzers are checked.

The result obtained by the analyzers is recorded and the output of the two analyzers is used to control valves in the discharge line, which automatically recycles the wastewater to the treatment feed tank if the mercury level approaches 50 µg/L.

The filtrate is also sampled by continuous samplers in order to provide 24-hour composite samples for laboratory mercury analyses. The Beauharnois plant discharge permit from the Quebec Ministry of the Environment required that mercury in the discharge be less than 2.5 g per tonne of chlorine produced. The limit is applied to the final combined site discharge which includes cooling water and runoff. This discharge is about 27,000 m^3/d and the plant has run consistently at about 7 percent of the mercury limit since the new acid sulphide precipitation treatment plant has been in operation.

The Province has an additional limitation which requires no waste to be discharged with a mercury concentration above 50 µg/L. The facility meets this requirement consistently.

The plant did not provide historical records of the treatment plant performance. However, they reported that the average influent mercury concentration was 20 mg/L, and treatment plant effluents were less than 20 µg/L. Effluents mercury levels exceeding 50 µg/L would never be discharged. as these would be recycled to front end of treatment process. The plant reports that effluent concentrations of 10 µg/L or less are achievable under good operation.

The solids removed in the filter contain approximately 1.5 percent mercury by weight. These wastes are currently being sent to a secure landfill in the United States.

The treatment plant is set up to be operated automatically. The same operator who runs the brine saturators in the brine perfication plant also runs the effluent treatment plant. The mercury analyzers are calibrated each weekday by an instrument technician.

The operation of the treatment plant at acid pH requires special precautions because of the potential hazard of a hydrogen sulphide escape (toxic/flammable). All drain lines are equipped with liquid seals. Reactors are covered and under negative pressure to prevent gas form escaping. Off gases form each reactor are scrubbed with alkaline solution and vented to the atmosphere personnel who enter the building carry a hydrogen sulphide personnel detector/alarm and monitors/alarms are located at strategic fixed locations through the building.

5.0 OBSERVATIONS

The use of membrane cell chlor-alkali technology can result in the elimination of mercury discharges from a chlor-alkali facility provided a successful site decontamination project is completed.

The effluent mercury removal process at this facility appears to achieve excellent, consistent results. Key elements identified include acid pH reaction conditions, large plate and frame filter presses, continuous filter aid addition, continuous mercury monitoring, and recycle of out-of-specification wastewater. Carbon adsorbent polishing methods proved unreliable and not necessary at this plant.

6.0 AUDIT TEAM

Mr. Peter Paine: Environment Canada
Dr. A. (Tony) Edmonds: Project Officer, MISA Office
Ms. Deborah Ross: CH2M HILL
Mr. Leo C. Ehrenreich: SAIC

APPENDIX

Figures

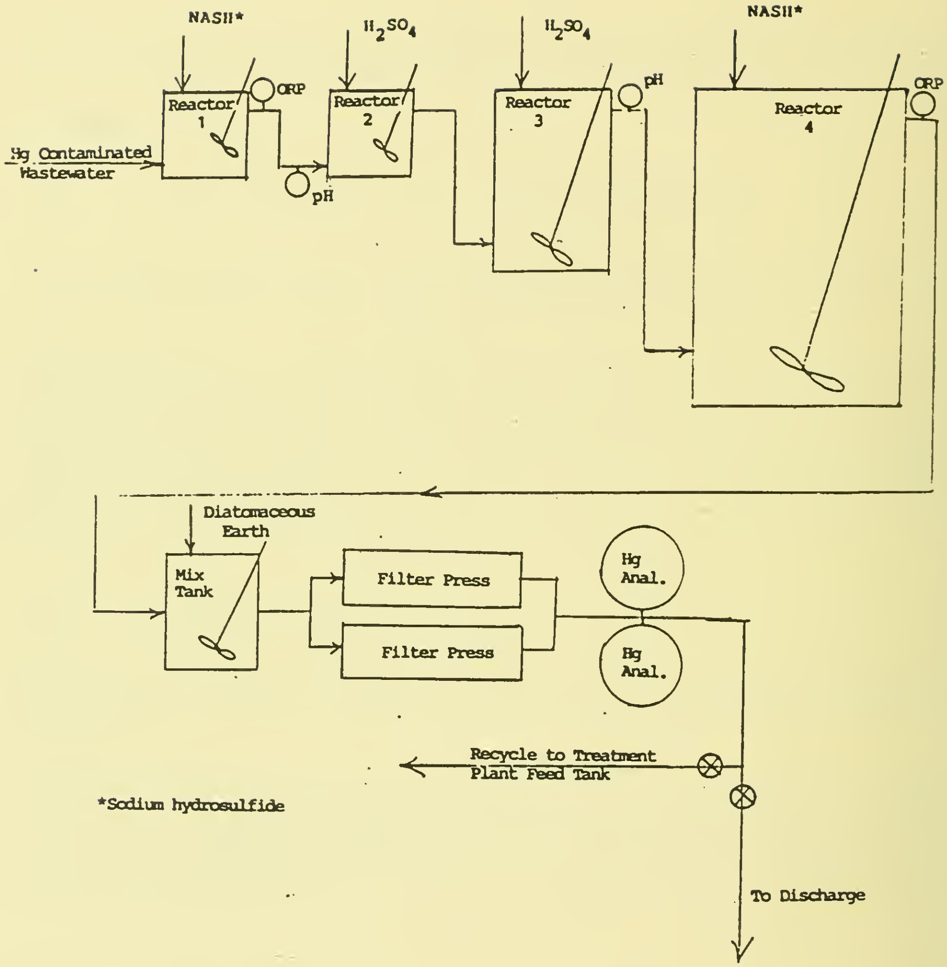


Figure A1

Mercury Wastewater Treatment Process (PPG Beauharnois, Quebec).

INORGANIC CHEMICAL SECTOR GLOBAL STUDY
SITE VISIT INFORMATION REPORT
EXPLOSIVES TECHNOLOGY INTERNATIONAL

1.0 PLANT SITE

ETI (Explosives Technology International)
Seneca Works
7700 West DuPont Road
Morris, IL 60450

Primary Contact:	J. D. (Doug) Puller Environmental Affairs Manager
Telephone:	(815) 357-8711
Additional Contacts:	Robert F. Wenger Technical Associate
	Michael W. Barendt Environmental Coordinator, Laboratory Supervisor
Date of Visit:	July 10, 1991

2.0 PLANT DESCRIPTION

The facility is located in a rural area in east central Illinois on the south bank of the Illinois River. The manufacturing area is located centrally on an approximately 5 square kilometre site to provide isolation. The site had been in continuous use for the manufacture of explosives since 1929 until recently. The facility has been operated by DuPont in the present configuration since 1976. ETI purchased the ammonium nitrate facility along with the TOVEX™ water gel explosives facility, and ammonium nitrate fuel oil (ANFO) lines when DuPont exited this business area.

ETI has ceased all production of TOVEX™ water gel explosives at the Seneca site. The former water gel plant is being decommissioned and was undergoing decontamination work during the visit.

Current production at the site is limited to the production of ammonium nitrate prills from ammonia and nitric acid. These prills are specially produced and priced for use in explosives. An emulsion explosives production facility is operated on an intermittent basis as required.

The southeast corner of the site is occupied by Reichhold Chemical Inc., who operate an acyclic adhesives manufacturing facility. This plant discharges to the ETI plant ditch which also receives all ETI process wastewater and stormwater runoff.

3.0 PROCESS DESCRIPTION

The facility manufactures nitric acid by burning ammonia, which is received by pipeline from a storage tank located on an adjacent property. The tank is served by barge from a U.S. Gulf coast source of ammonia. The acid produced is reacted with ammonia to form ammonium nitrate which is prilled on site at the rate of about 560 tonnes/d. Additives and prilling conditions are controlled to produce prills which are physically robust and absorb oil easily, for use in ANFO explosives. These prills can be sold at a premium when compared to prills for fertilizer uses.

The water gel explosives facility at this site is being decommissioned. It no longer produces product or wastewater. The emulsion explosives plant which produces oxidants and blasting agents is only operated intermittently as demand requires. It also produces virtually no wastewater. No other explosives operations are in production. Virtually, all wastewater generated on site is from a product of the ammonium nitrate operations and surface runoff.

4.0 WATER MANAGEMENT

4.1 Water Supply

Wells supply 3,000 m^3/d for all process related uses.

4.2 Sources of Wastewater

Figure A.a in the Appendix presents an overall layout map from the facility. The plant ditch, a natural drainage ditch that traverses the site, is used to collect all process wastewater and runoff.

The NPDES permit application filed in 1987 which describes the wastewater flows at that time is included in the Appendix. At the present time, the flow from the "Overland Flow" process is zero and the flows from the water gel plant and the emulsion plant are virtually zero. The sanitary flow is small and will be further reduced as a result of a reduced labour force.

4.3 Sewer Segregation

All process and storm flows enter the same collection system.

5.0 WASTEWATER TREATMENT

5.1 Sanitary Wastewater

Sanitary wastewater from the facility and the adjoining Reichhold plant are treated in small package plants and then discharged to the plant ditch.

5.2 Process Wastewater Pretreatment

The plant does not employ any wastewater pretreatment processes.

5.3 Wastewater Management and Treatment

This facility is utilizing a series of naturally occurring ponds, which had formed on the flat lands adjoining the Illinois River, for treatment of their wastewater. Figure A.1 shows the relative size and location of the ponds. The facility has a 45 kg/d limit on ammonia nitrogen. The inlet of Pond 1 and the outlet of Pond 2 (which is the monitoring point for their discharge) are sampled daily for NH_3-N levels. The loading at the discharge is calculated, and the loading at the inlet is slowly increased or decreased depending on the outlet loading compared to the allowed 45 kg/d. The loading of the inlet is adjusted by flow control on the discharge from a large lined storage lagoon or when necessary by restricting the runoff flow from the area which was formerly used for overland flow, and which still produces a high nitrogen load during heavy runoff.

The storage lagoon has a capacity of about 57,000 m^3. The storage lagoon ammonia nitrogen concentration is about 10,000 mg/L. This lagoon is used to accumulate runoff from contaminated areas, washdowns, and cooling tower blowdown from the nitric acid, ammonium nitrate production areas. During winter months, the pond is used for storage and as the weather improves, the level of the pond is reduced consistent with the treatment capabilities of the vegetation in the ponds.

During the site visit, influent to the pond system was 90 kg/d of ammonia nitrogen and effluent of 1.4 kg/d was discharged. The pond inlet loading will be increased gradually to reduce the inventory of concentrated waste.

In past summers, the pond system has handled inlet loading rates of up to 450 kg/d. This ten-fold reduction is reported as normal for summer operation. During winter months, the ponds still achieve about a two-fold reduction, but the loading is controlled by accumulating the concentrated waste in the storage lagoon. During the past 12-month period, the only time the facility has exceeded the 45 kg limit was for several days in March 1991, which followed a period of prolonged heavy rain and some lowland flooding along the river.

Pond 1 is covered with algae growth and is vegetated with grasses and cattails. The pond is very shallow (about 0.5 m) and has a nominal residence time of one day. The first pond overflows to a drain in the area that separates Pond 1 from Pond 2. The second pond provides 1 1/2- to 2-day holdup with a depth of 0.6 to 1 meters.

During the winter months, Pond 2 tends to freeze along the south side in late December until late February and short circuits somewhat with an estimated 50 percent reduction in holdup time.

The two ponds are clearly providing a nitrification-denitrification treatment. The waste from the adhesive plant and the sanitary sewage, as well as decaying vegetation all combine to provide sufficient organic nutrients for the process.

In the past, the facility used a land farming approach in which the concentrated wastes from the lagoon were diluted with sufficient fresh water to bring the concentration down low enough for spray application on grasses. These grasses were specially selected for high nitrogen uptake. This treatment method was abandoned due to high ammonia levels in storm runoff from the irrigated fields. The discontinuance of this practice also resulted in a 10 percent reduction in flow to the pond system.

A review of the permit record for the facility from the mid-1970's discloses that discharge loading was in the 500 kg/d range. The 45 kg/d limit was eventually imposed after an extended period of hearings and appeals. The 45 kg/d limit appears to be related to an Illinois state statute which required that the load of pollutants from an industrial facility cannot be greater than the load produced by a population of 50,000 residents. This limit predates the federal effluent guidelines.

6.0 MONITORING DATA

Appendix B is a copy of selected parts of the most recent NPDES permit application for the facility. The NPDES Permit No. IL 0001767 covers the facility. The application includes a summary of monitoring data for a one-year period along with a Priority Pollutant Scan. The application also contains limited data for monomethylamine and monomethylamine nitrate, substances which are no longer in use at the site.

Based on the current nominal average flow of about 3,000 m^3/d, the outlet concentration at the 45 kg load limit would be 15 mg/L. This would imply inlet concentrations of 150 mg/L could be handled in the summer, and 30 mg/L in the freeze-over conditions at the same nominal flow.

7.0 BEST MANAGEMENT PRACTICES

The primary reason for visiting this site was to obtain information on the process which was used to recycle off spec and process wastes from the water gel manufacturing plant. An open burning approach safely disposes of these relatively dangerous wastes but has some air pollution and possible contaminated stormwater runoff problems. The ETI Seneca facility was forced by regulators to abandon the open burning approach about 25 years ago because of the smoke from the paper and fuel.

A process was developed by the Seneca Plant for recovery of these wastes. The concentrated recovered nitrate solution is then used in formulating new product. The initial hydrolysis of gelling agents must be under acid conditions and, therefore, due to the metals present in the waste product, there is considerable potential for fire or explosion of fine aluminium powder present in other products.

Over the years, they have had minor fires in this hydrolysis unit on three occasions. In each case, the problem was contained. A flow diagram of the recycle process along with a narrative description of the process is provided in the Appendix. It is the opinion of Robert Wenger of ETI, who is familiar with the development of the recycle process as well as the waste burning procedure, that the burning process is much less hazardous and, therefore, should be preferred.

8.0 OBSERVATIONS

The water gel recycle process, although proven feasible by successful operation at the Seneca Plant, appears at best marginal from a safety standpoint.

The operation of the plant's wastewater management and treatment system to meet the 45 kg/d of ammonia nitrogen depends upon the close attention of the facility personnel. The approach substitutes labour and management for capital and technology. This approach is somewhat vulnerable to rainfall upsets and is somewhat dependent on a cheap organic nutrient source, but it does demonstrate that even simple nitrification processes will work on wastes from an ammonium nitrate plant.

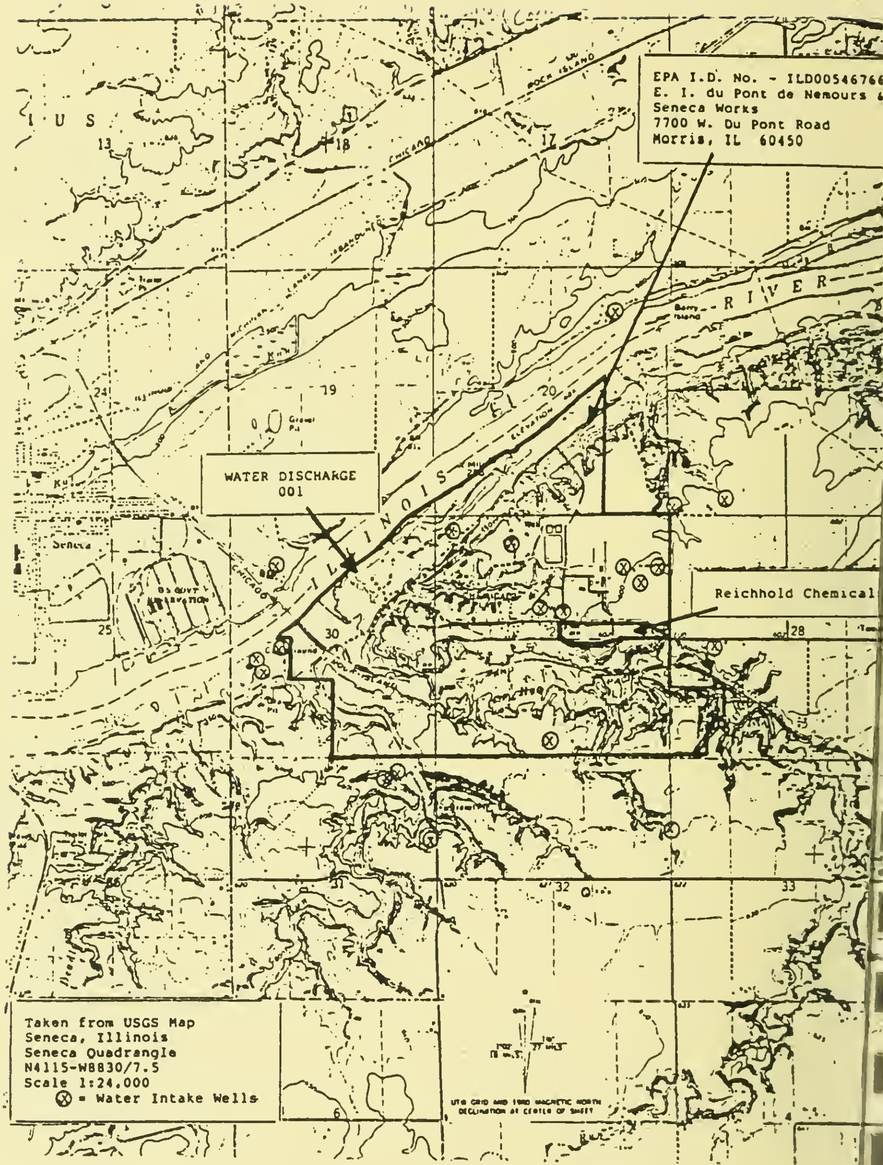
During conversations and review of the regulatory record with ETI personnel, it was found that DuPont in the mid-1970's had investigated other possible approaches to managing the ammonia load at Seneca. This was during a time frame in which DuPont was opposing the 45 kg/d ammonia load limit. An approach based on ion exchange which was to recover usable concentrations (30-35 percent) of ammonium nitrate from the lagoon storage system water was evaluated. It was thought this material could then be utilized for nitrogen fertilizer applications. DuPont actually committed to the approach and committed $3,500,000 to build a unit. The supplier was identified as the Chemical Separation Corporation of Knoxville, Tennessee. Early in the project, the decision was reversed because in 1976 a fire occurred in a similar Chemical Separation system at a C-F Industries facility in Chattanooga, Tennessee possibly caused by overheating during regeneration with nitric acid/ammonia solvents. An additional problem area with the approach was in developing a plan to sell or dispose of the concentrated ammonium nitrate regenerate stream. DuPont incurred considerable expense in cancelling the project and in its place adopted a "land farming" approach.

9.0 AUDIT TEAM

Ms. Eleanor Young	CH2M HILL
Mr. Leo Ehrenreich	SAIC
Dr. A. (Tony) Edmonds	Project Officer, MISA Office

APPENDIX

- Figure
- NPDES Abstract
- Water Gel Hydrolysis Process


EPA I.D. No. - ILD00546766
E. I. du Pont de Nemours
Seneca Works
7700 W. Du Pont Road
Morris, IL 60450

Taken from USGS Map
Seneca, Illinois
Seneca Quadrangle
N4115-W8830/7.5
Scale 1:24,000
⊗ = Water Intake Wells

Figure A1

APPENDIX

NPDES Permit Abstract

DU PONT
ESTABLISHED 1802
E. I. DU PONT DE NEMOURS & COMPANY
INCORPORATED
MORRIS, ILLINOIS 60450

INISHES & FABRICATED PRODUCTS
ENECA WORKS
700 WEST DU PONT ROAD

April 15, 1987

Illinois Environmental Protection Agency
Division of Water Pollution Control
Permit Section, No. 15
2200 Churchill Road
Springfield, IL 62706

Dear Sirs:

NPDES PERMIT NO. IL0001767 RENEWAL APPLICATION

Renewal of our current NPDES Permit No. IL0001767 is requested. Completed Forms 1 and 2c are attached.

The plant's current NPDES Permit No. IL0001767 includes semiannual monitoring in Special Conditions 3 and 6 for:

- Barium
- Cadmium
- Copper
- Fluoride
- Iron
- Lead
- Manganese
- Mercury
- Nickel
- Oils, Fats, & Greases
- Phenols
- Selenium
- Monomethylamine
- Monomethylamine Nitrate

Based upon the analysis experience that has now been collected for these materials, it is requested that these special conditions be dropped from the permit.

If there are any questions, please contact me at (815) 357-8711, Extension 281.

Very truly yours,

J. R. BAKER, MANAGER

J. D. Puller

J. D. Puller
S-H-E Coordinator

JDP/vhh

FORM
1
ENERAL

EPA

U.S. ENVIRONMENTAL PROTECTION AGENCY

GENERAL INFORMATION

Consolidated Permits Program

(Read the "General Instructions" before starting.)

F	ILD005467667	D

LABEL ITEMS	
EPA I.D. NUMBER	PLEASE PLACE LABEL IN THIS SPACE
FACILITY NAME	
FACILITY MAILING ADDRESS	
FACILITY LOCATION	

GENERAL INSTRUCTIONS

If a preprinted label has been provided, affix it in the designated space. Review the information carefully; if any of it is incorrect, cross through it and enter the correct data in the appropriate fill–in area below. Also, if any of the preprinted data is absent *(the area to the left of the label space lists the information that should appear)*, please provide it in the proper fill–in area(s) below. If the label is complete and correct, you need not complete Items I, III, V, and VI *(except VI-B which must be completed regardless)*. Complete all items if no label has been provided. Refer to the instructions for detailed item descriptions and for the legal authorizations under which this data is collected.

POLLUTANT CHARACTERISTICS

NSTRUCTIONS: Complete A through J to determine whether you need to submit any permit application forms to the EPA. If you answer "yes" to any uestions, you must submit this form and the supplemental form listed in the parenthesis following the question. Mark "X" in the box in the third column the supplemental form is attached. If you answer "no" to each question, you need not submit any of these forms. You may answer "no" if your activity excluded from permit requirements; see Section C of the instructions. See also, Section D of the instructions for definitions of bold–faced terms.

SPECIFIC QUESTIONS	MARK 'X' YES	NO	FORM ATTACHED	SPECIFIC QUESTIONS	MARK 'X' YES	NO	FORM ATTACHED
. Is this facility a publicly owned treatment works which results in a discharge to waters of the U.S.? (FORM 2A)		X		B. Does or will this facility *(either existing or proposed)* include a concentrated animal feeding operation or aquatic animal production facility which results in a discharge to waters of the U.S.? (FORM 2B)		X	
. Is this a facility which currently results in discharges to waters of the U.S. other than those described in A or B above? (FORM 2C)	X		X	D. Is this a proposed facility *(other than those described in A or B above)* which will result in a discharge to waters of the U.S.? (FORM 2D)		X	
. Does or will this facility treat, store, or dispose of hazardous wastes? (FORM 3)		X		F. Do you or will you inject at this facility industrial or municipal effluent below the lowermost stratum containing, within one quarter mile of the well bore, underground sources of drinking water? (FORM 4)		X	
. Do you or will you inject at this facility any produced water or other fluids which are brought to the surface in connection with conventional oil or natural gas production, inject fluids used for enhanced recovery of oil or natural gas, or inject fluids for storage of liquid hydrocarbons? (FORM 4)		X		H. Do you or will you inject at this facility fluids for special processes such as mining of sulfur by the Frasch process, solution mining of minerals, in situ combustion of fossil fuel, or recovery of geothermal energy? (FORM 4)		X	
Is this facility a proposed stationary source which is one of the 28 industrial categories listed in the instructions and which will potentially emit 100 tons per year of any air pollutant regulated under the Clean Air Act and may affect or be located in an attainment area? (FORM 5)		X		J. Is this facility a proposed stationary source which is NOT one of the 28 industrial categories listed in the instructions and which will potentially emit 250 tons per year of any air pollutant regulated under the Clean Air Act and may affect or be located in an attainment area? (FORM 5)		X	

NAME OF FACILITY

SKIP E.I. du Pont de Nemours & Company

FACILITY CONTACT

A. NAME & TITLE *(last, first, & title)*	B. PHONE *(area code & no.)*
Puller J.D. Environmental Coor	815 357 8711

FACILITY MAILING ADDRESS

A. STREET OR P.O. BOX
7700 W. Du Pont Road

B. CITY OR TOWN	C. STATE	D. ZIP CODE
Morris	IL	60450

FACILITY LOCATION

A. STREET, ROUTE NO. OR OTHER SPECIFIC IDENTIFIER
7700 W. Du Pont Road

B. COUNTY NAME
Grundy

C. CITY OR TOWN	D. STATE	E. ZIP CODE	F. COUNTY CODE *(if known)*
Morris	IL	60450	

CONTINUE ON REVERSE

CONTINUED FROM THE FRONT

VII. SIC CODES (4-digit, in order of priority)

A. FIRST	**B. SECOND**
C 7 2892 (specify) Explosives	C 7 2819 (specify) Nitric Acid and Ammonium Nitrate Manufacturing
C. THIRD	**D. FOURTH**
C 7 2891 (specify) Industrial Adhesives Manufacturing (Reichhold Chemicals, Inc.)	C 7 (specify) N/A

VIII. OPERATOR INFORMATION

A. NAME

C 8 E. I. du Pont de Nemours & Company

B. Is the name l… Item VIII-A … owner?

☒ YES ☐

C. STATUS OF OPERATOR (Enter the appropriate letter into the answer box; if "Other", specify.)

F = FEDERAL
S = STATE
P = PRIVATE
M = PUBLIC (other than federal or state)
O = OTHER (specify)

P (specify)

D. PHONE (area code & no.)

C A 302 774 389

E. STREET OR P.O. BOX

1007 Market Street

F. CITY OR TOWN	G. STATE	H. ZIP CODE
C B Wilmington	DE	19898

IX. INDIAN LAND

Is the facility located on Indian lands?

☐ YES ☒ NO

X. EXISTING ENVIRONMENTAL PERMITS

A. NPDES (Discharges to Surface Water)	**D. PSD** (Air Emissions from Proposed Sources)
N IL0001767	9 P N/A
B. UIC (Underground Injection of Fluids)	**E. OTHER** (specify)
9 U N/A	9 Air (specify) See attached
C. RCRA (Hazardous Wastes)	**E. OTHER** (specify)
9 R N/A	9 N/A (specify)

XI. MAP

Attach to this application a topographic map of the area extending to at least one mile beyond property bounderies. The map must sho the outline of the facility, the location of each of its existing and proposed intake and discharge structures, each of its hazardous was treatment, storage, or disposal facilities, and each well where it injects fluids underground. Include all springs, rivers and other surfa water bodies in the map area. See instructions for precise requirements.

XII. NATURE OF BUSINESS (provide a brief description)

Seneca Works is a chemical manufacturing plant with four major products: Tovex® Water Gel Explosives, Emulsion Products (oxidants and blasting agents), Nitric Acid and Ammonium Nitrate.

The Adhesives Manufacturing Facility (SIC 2891) is actually Reichhold Chemicals, Inc. whic was formerly owned and operated by E. I. du Pont de Nemours & Co., Inc. The discharge fro this operation is still a part of E. I. du Pont's Discharge 001.

XIII. CERTIFICATION (see instructions)

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this application and attachments and that, based on my inquiry of those persons immediately responsible for obtaining the information contained in application, I believe that the information is true, accurate and complete. I am aware that there are significant penalties for submit false information, including the possibility of fine and imprisonment.

A. NAME & OFFICIAL TITLE (type or print)	B. SIGNATURE	C. DATE SIGNED
B. A. Beardwood, Vice President Fabricated Products	BABeardwood	4/5/87

COMMENTS FOR OFFICIAL USE ONLY

C

EPA I.D. Number - ILD005467667

E. I. du Pont de Nemours & Company
Seneca Works
7700 W. Du Pont Road
Morris, IL 60450

ILLINOIS EPA - DIVISION OF AIR POLLUTION
OPERATING PERMITS

eration	Application No. Permit No.	Identification Number	Current Permit Issue Date	Current Permit Expiration Date
ll Plant	74060137	063813AAE	11/19/85	9/18/90
3 AOP	72111200	063813AAE	11/21/86	12/31/88
	74090092	063813AAE	12/24/84	12/24/89
6 Boiler	73120060	063813AAE	6/22/83	6/22/88
n Burning nnual)	B8505030	063813	6/03/86	6/02/87
5 Boiler	81020051	063813AAE	3/10/81	10/09/90

/vhh

or type in the unshaded areas only

ORM
C
DES

U S ENVIRONMENTAL PROTECTION AGENCY
APPLICATION FOR PERMIT TO DISCHARGE WASTEWATER
EXISTING MANUFACTURING, COMMERCIAL, MINING AND SILVICULTURAL OPERATIONS
Consolidated Permits Program

OUTFALL LOCATION

or each outfall, list the latitude and longitude of its location to the nearest 15 seconds and the name of the receiving water.

OUTFALL NUMBER (list)	B. LATITUDE			C. LONGITUDE			D. RECEIVING WATER *(name)*
	1. DEG	2. MIN	3. SEC	1. DEG.	2. MIN	3. SEC	
001	41	18	30	88	34	50	Illinois River

FLOWS, SOURCES OF POLLUTION, AND TREATMENT TECHNOLOGIES

Attach a line drawing showing the water flow through the facility. Indicate sources of intake water, operations contributing wastewater to the eff and treatment units labeled to correspond to the more detailed descriptions in Item B. Construct a water balance on the line drawing by showing aver flows between intakes, operations, treatment units, and outfalls. If a water balance cannot be determined *(e.g., for certain mining activities)*, provid pictorial description of the nature and amount of any sources of water and any collection or treatment measures.

For each outfall, provide a description of: (1) All operations contributing wastewater to the effluent, including process wastewater, sanitary wastewater, cooling water, and storm water runoff; (2) The average flow contributed by each operation; and (3) The treatment received by the wastewater. Continu on additional sheets if necessary.

OUT-FALL NO (list)	2. OPERATION(S) CONTRIBUTING FLOW		3. TREATMENT		
	a. OPERATION *(list)*	b. AVERAGE FLOW *(include units)*	a. DESCRIPTION	b. LIST CODES FRO TABLE 2C-1	
1	No. 3 Nitric Acid and Ammonium Nitrate Prill Plant (Boiler and Cooling Tower Blowdown and Process Water)	354,000 GPD	Facultative Ponds, Overland Flow (Spray Plots)	3D 3F	3G
1	Sanitary Wastewater Systems	13,000 GPD	Activated Sludge, Facultative Ponds	3A	3G
1	Tovex® Water Gel Plant (Stormwater Dike Drainage, Cooling Tower Blowdown)	16,000 GPD	Facultative Ponds	3D	3G
1	Emulsion Plant (Stormwater Drainage, Non-Contact Cooling)	29,000 GPD	Facultative Ponds	3D	3G
1	Power House (Boiler Blowdown, Water Softening Backwash)	57,000 GPD	Facultative Ponds	3G	

FICIAL USE ONLY *(effluent guidelines sub-categories)*

ILD005467667

Approval expires / 31·00

ILD005467667

U S ENVIRONMENTAL PROTECTION AGENCY
APPLICATION FOR PERMIT TO DISCHARGE WASTEWATER
EXISTING MANUFACTURING, COMMERCIAL, MINING AND SILVICULTURAL OPERATIONS
Consolidated Permits Program

FALL LOCATION

ch outfa , list the latitude and longitude of its location to the nearest 15 seconds and the name of the receiving water

FALL BER	B. LATITUDE			C. LONGITUDE			D. RECEIVING WATER *(name)*
	1. DEG	2. MIN	3. SEC	1. DEG	2. MIN	3. SEC	

WS, SOURCES OF POLLUTION, AND TREATMENT TECHNOLOGIES

a line drawing showing the water flow through the facility. Indicate sources of intake water, operations contributing wastewater to the effluent, treatment units labeled to correspond to the more detailed descriptions in Item B. Construct a water balance on the line drawing by showing average s between intakes, operations, treatment units, and outfalls. If a water balance cannot be determined *(e.g., for certain mining activities)*, provide a ria description of the nature and amount of any sources of water and any collection or treatment measures.

each outfall, provide a description of: (1) All operations contributing wastewater to the effluent, including process wastewater, sanitary wastewater, ing water, and storm water runoff; (2) The average flow contributed by each operation; and (3) The treatment received by the wastewater. Continue dditional sheets if necessary

2. OPERATION(S) CONTRIBUTING FLOW		3. TREATMENT		
a. OPERATION *(list)*	b. AVERAGE FLOW *(include units)*	a. DESCRIPTION	b. LIST CODES FROM TABLE 2C-1	
Reichhold Chemicals, Inc.	46,000 GPD	Flocculation,	1G	3G
Plant (Cooling Tower		Facultative Ponds		
Blowdown, Process Water)				
Plantwide Stormwater	269,000 GPD	Facultative Ponds	3G	
Runoff				
Reservoir Overflow	216,000 GPD	Facultative Ponds	3G	

TINUED FROM THE FRONT

xcept for storm runoff, leaks, or spills, are any of the discharges described in Items II-A or B intermittent or seasonal?

☐ YES *(complete the following table)* ☒ NO *(go to Section III)*

UTFALL JMBER *(list)*	2. OPERATION*(s)* CONTRIBUTING FLOW *(list)*	3. FREQUENCY		4. FLOW				
		a. DAYS PER WEEK *(specify average)*	b. MONTHS PER YEAR *(specify average)*	a. FLOW RATE *(in mgd)*		b. TOTAL VOLUME *(specify with units)*		c. DURATION *(in days)*
				1. LONG TERM AVERAGE	2. MAXIMUM DAILY	1. LONG TERM AVERAGE	2. MAXIMUM DAILY	

RODUCTION

Does an effluent guideline limitation promulgated by EPA under Section 304 of the Clean Water Act apply to your facility?

☐ YES *(complete Item III-B)* ☒ NO *(go to Section IV)*

Are the limitations in the applicable effluent guideline expressed in terms of production *(or other measure of operation)*?

☐ YES *(complete Item III-C)* ☐ NO *(go to Section IV)*

If you answered "yes" to Item III-B, list the quantity which represents an actual measurement of your level of production, expressed in the terms and units used in the applicable effluent guideline, and indicate the affected outfalls.

1. AVERAGE DAILY PRODUCTION			2. AFFECTED OUTFALLS *(list outfall numbers)*
QUANTITY PER DAY	b. UNITS OF MEASURE	c. OPERATION, PRODUCT, MATERIAL, ETC. *(specify)*	

MPROVEMENTS

re you now required by any Federal, State or local authority to meet any implementation schedule for the construction, upgrading or operation of wastewater treatment equipment or practices or any other environmental programs which may affect the discharges described in this application? This includes, ut is not limited to, permit conditions, administrative or enforcement orders, enforcement compliance schedule letters, stipulations, court orders, and grant r loan conditions.

☐ YES *(complete the following table)* ☒ NO *(go to Item IV-B)*

NTIFICATION OF CONDITION, AGREEMENT, ETC.	2. AFFECTED OUTFALLS		3. BRIEF DESCRIPTION OF PROJECT	4. FINAL COMPLIANCE DATE	
	a. NO.	b. SOURCE OF DISCHARGE		a. REQUIRED	b. PROJECTED

PTIONAL: You may attach additional sheets describing any additional water pollution control programs *(or other environmental projects which may affec our discharges)* you now have underway or which you plan. Indicate whether each program is now underway or planned, and indicate your actual o lanned schedules for construction. ☐

: to storm runoff, leaks, or spills, are any of the discharges described in Items II-A or B intermittent or seasonal?

☐ YES (complete the following table) ☐ NO (go to Section III)

ALL ER	2. OPERATION(s) CONTRIBUTING FLOW (list)	3. FREQUENCY		4. FLOW				
		a. DAYS PER WEEK (specify average)	b. MONTHS PER YEAR (specify average)	a. FLOW RATE (in mgd)		b. TOTAL VOLUME (specify with units)		c. DUR ATION (in da
				1. LONG TERM AVERAGE	2. MAXIMUM DAILY	1. LONG TERM AVERAGE	2. MAXIMUM DAILY	

ODUCTION

an effluent guideline limitation promulgated by EPA under Section 304 of the Clean Water Act apply to your facility?

☐ YES (complete Item III B) ☐ NO (go to Section IV)

the limitations in the applicable effluent guideline expressed in terms of production (or other measure of operation)?

☐ YES (complete Item III C) ☐ NO (go to Section IV)

u answered "yes" to Item III-B, list the quantity which represents an actual measurement of your level of production, expressed in the terms and units d in the applicable effluent guideline, and indicate the affected outfalls

1. AVERAGE DAILY PRODUCTION			2. AFFECTED OUTFALLS (list outfall numbers)
NTITY PER DAY	b. UNITS OF MEASURE	c. OPERATION, PRODUCT, MATERIAL, ETC. (specify)	

ROVEMENTS

you now required by any Federal, State or local authority to meet any implementation schedule for the construction, upgrading or operation of waste- r treatment equipment or practices or any other environmental programs which may affect the discharges described in this application? This includes, s not limited to, permit conditions, administrative or enforcement orders, enforcement compliance schedule letters, stipulations, court orders, and grant an conditions.

☐ YES (complete the following table) ☐ NO (go to Item IV-B)

IFICATION OF CONDITION, AGREEMENT, ETC.	2. AFFECTED OUTFALLS		3. BRIEF DESCRIPTION OF PROJECT	4. FINAL COMPLIANCE DATE	
	a. NO.	b. SOURCE OF DISCHARGE		a. REQUIRED	b. PROJECTED

IONAL: You may attach additional sheets describing any additional water pollution control programs (or other environmental projects which may affect r discharges) you now have underway or which you plan. Indicate whether each program is now underway or planned, and indicate your actual or ned schedules for construction. ☐ MARK "X" IF DESCRIPTION OF ADDITIONAL CONTROL PROGRAMS IS ATTACHED

NUED FROM THE FRONT

BIOLOGICAL TOXICITY TESTING DATA

you have any knowledge or reason to believe that any biological test for acute or chronic toxicity has been made on any of your discharges or on a
eiving water in relation to your discharge within the last 3 years?

☐ YES *(identify the test(s) and describe their purposes below)* ☒ NO *(go to Section VIII)*

ONTRACT ANALYSIS INFORMATION

re any of the analyses reported in Item V performed by a contract laboratory or consulting firm?

☒ YES *(list the name, address, and telephone number of, and pollutants analyzed by, each such laboratory or firm below)* ☐ NO *(go to Section IX)*

A. NAME	B. ADDRESS	C. TELEPHONE *(area code & no.)*	D. POLLUTANTS ANALYZED *(list)*
RRO Laboratories, Inc.	P. O. Box 686 Caton Farm Road Joliet, IL 60434	(815)727-5436	Reference Attachment

ERTIFICATION

tify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed t
re that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system o
e persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete
aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

NAME & OFFICIAL TITLE *(type or print)*
B. A. Beardwood
Vice President - Fabricated Products

B. PHONE NO. *(area code & no.)*
(302) 774-3891

SIGNATURE

D. DATE SIGNED
4/15/87

UED FROM PAGE 2

EPA I.D. NUMBER (copy from Item 1 of Form 1)
ILD005467667

OMB No. [illegible]
Approval expires 7-31-88

AKE AND EFFLUENT CHARACTERISTICS

C: See instructions before proceeding – Complete one set of tables for each outfall – Annotate the outfall number in the space provided.
NOTE Tables V-A, V-B, and V-C are included on separate sheets numbered V-1 through V-9.

e the space below to list any of the pollutants listed in Table 2c-3 of the instructions, which you know or have reason to believe is discharged or may be scharged from any outfall. For every pollutant you list, briefly describe the reasons you believe it to be present and report any analytical data in your ssession.

1. POLLUTANT	2. SOURCE	1. POLLUTANT	2. SOURCE
omethylamine and omethylamine Nitrate	May be present if an uncontrolled spill occurred (area is diked). Last three analyses of total MMA and MMAN: March 1986 LT 4 ppm June 1986 LT 1 ppm Jan. 1987 LT 1 ppm LT (Less Than)	Ion chromatography was selected in 1985 as the best experimental method for this analysis with a minimum detection limit of 4 ppm. Subsequent improvements in the method through experience have lowered the minimum detection limit to 1 ppm. All monitoring has indicated the absence of both MMA and MMAN at these minimum detection limits.	

TENTIAL DISCHARGES NOT COVERED BY ANALYSIS

pollutant listed in Item V-C a substance or a component of a substance which you currently use or manufacture as an intermediate or final product or duct?

☐ YES (list all such pollutants below) ☒ NO (go to Item VI-B)

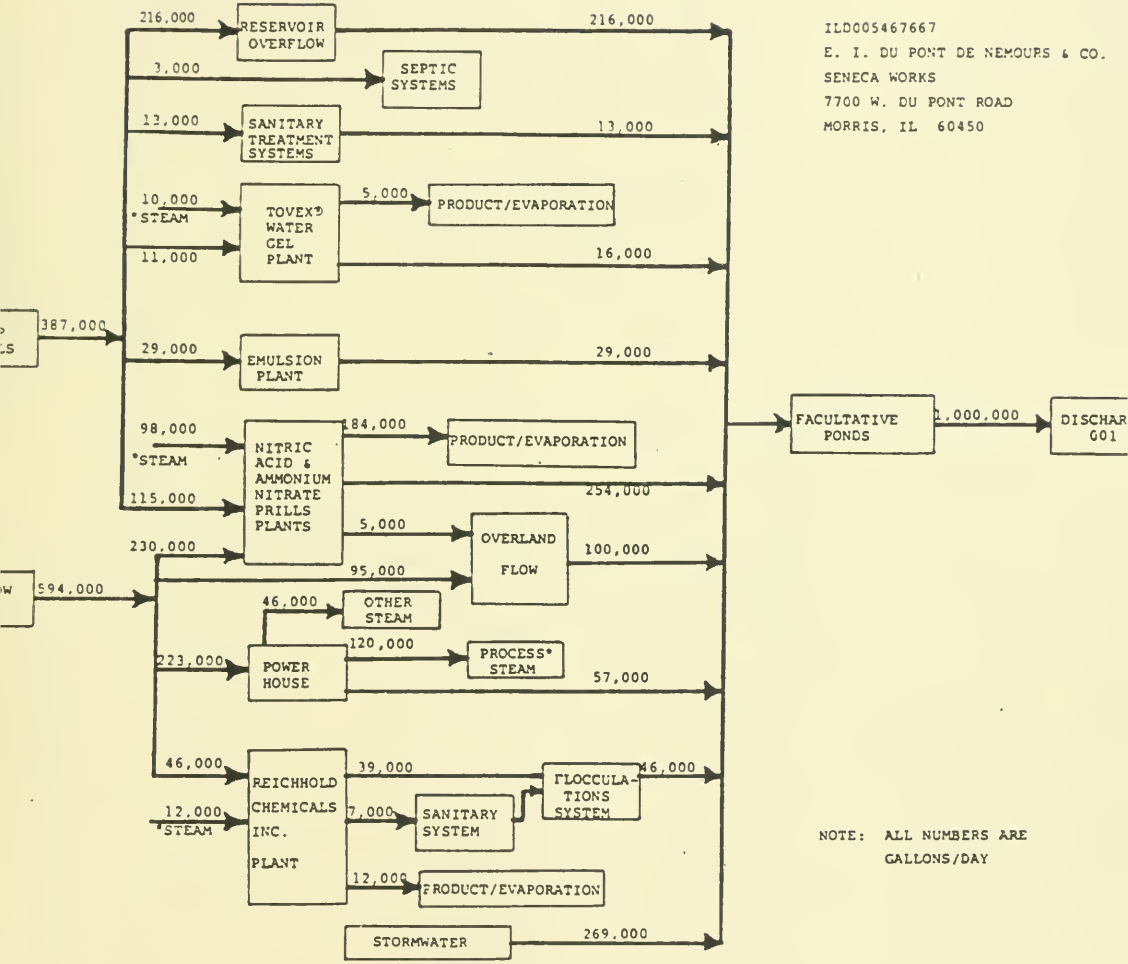
ILD005467667

E. I. du Pont de Nemours & Company, Inc.
7700 W. Du Pont Road
Morris, IL 60450

VIII. (D) Pollutants Analyzed by ARRO Laboratories, Inc.

COD
TOC
Color
Fecal Coliform
Nitrate - Nitrite
Nitrogen, Total Organic
Phosphorus
Sulfate
Sulfide
Sulfite
Surfactants
Aluminum
Magnesium
Antimony
Arsenic
Beryllium
Silver
Thallium
Cyanide
GC/MS Fraction - Volatile Compounds
GC/MS Fraction - Acid Compounds
GC/MS Fraction - Base/Neutral Compounds
Oil and Grease
Barium
Iron
Manganese
Cadmium
Copper
Lead
Mercury
Nickel
Selenium
Zinc
Phenols
Chromium

FORM 2C - PART IIA
WATER FLOW LINE DRAWING



ILD005467667
E. I. DU PONT DE NEMOURS & CO.
SENECA WORKS
7700 W. DU PONT ROAD
MORRIS, IL 60450

NOTE: ALL NUMBERS ARE GALLONS/DAY

ILD005467667

E. I. DU PONT DE NEMOURS & COMPANY
SENECA WORKS
7700 W. DU PONT ROAD
MORRIS, IL 60450

PRIORITY POLLUTANT DATA

EXPLANATION SHEET

Abbreviations

N/A = Not Applicable

LT = Less Than

This term is used when the analysis indicates the item was not detectable at the lower limit of the analysis method. The concentration value shown is the lower detectable limit of the analysis method.

MGD = Million gallons per day

Mg/l = Milligrams per liter

Lbs./day = Pounds per day

ASE PRINT OR TYPE IN THE UNSHADED AREAS ONLY. You may report some or all of information on separate sheets (use the same format) instead of completing these pages.
INSTRUCTIONS

EPA I.D. NUMBER (copy from Item 1 of Form 1)
ILD005467667

Form Approved
OMB No. 2040 0086,
Approval expires 7-31-88

OUTFALL NO
001

INTAKE AND EFFLUENT CHARACTERISTICS (continued from page 3 of Form 2-C)

ART A - You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall. See instructions for additional details.

POLLUTANT	2. EFFLUENT							3. UNITS (specify if blank)		4. INTAKE (optional)		
	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSE
	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
iochemical ygen Demand D)	54.35	403.90	25.50	211.35	19.06	142.08	104	mg/1	lb./day			
Chemical ygen Demand D)	LT 20	LT 167.28	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Total Organic bon (TOC)	13.0	108.73	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Total Suspended ids (TSS)	52.00	429.26	25.22	151.01	13.24	92.68	104	mg/1	lb./day			
Ammonia (as N)	11.80	100.61	5.41	49.33	2.85	23.10	104	mg/1	lb./day			
Flow	VALUE 3.00		VALUE 1.10		VALUE 0.96		365		MGD	VALUE		
Temperature inter)	VALUE 15		VALUE 8.8		VALUE 8.5		34	°C		VALUE		
Temperature ummer)	VALUE 31		VALUE 26.9		VALUE 30.0		70	°C		VALUE		
pH	MINIMUM 7.16	MAXIMUM 8.80	MINIMUM 7.73	MAXIMUM 8.19			104	STANDARD UNITS				

ART B - Mark "X" in column 2-a for each pollutant you know or have reason to believe is present. Mark "X" in column 2-b for each pollutant you believe to be absent. If you mark column 2a for any polluta which is limited either directly, or indirectly but expressly, in an effluent limitations guideline, you must provide the results of at least one analysis for that pollutant. For other pollutants for which you ma column 2a, you must provide quantitative data or an explanation of their presence in your discharge. Complete one table for each outfall. See the instructions for additional details and requiremen

. POLLUTANT AND CAS NO. (if available)	2. MARK "X"		3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. BELIEVED PRESENT	b. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. ANA YSE
			(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
Bromide 24959-67-9)		X												
Chlorine, otal Residual	X		0.19	1.18	0.04	0.25	0.01	0.10	104	mg/1	lb./day			
. Color	X		LT 5	N/A	N/A	N/A	N/A	N/A	1	Color Units	N/A			
. Fecal Coliform	X		LT 1	N/A	N/A	N/A	N/A	N/A	1	No/100 ml	N/A			
Fluoride 16984-48-8)		X												
Nitrate-Nitrite (as N)	X		16.14	134.99	N/A	N/A	N/A	N/A	1	mg/1	lb./day			

CONTINUE ON REVERS

M V R CONTINUED FROM FRONT

OLLUT-NT AND AS NO. available)	2. MARK 'X'		3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. BELIEVED PRESENT	b. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO AN YS
			(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
itrogen, al Organic N)	X		5.6	46.84	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Oil and	X		6.0	41.82	N/A	N/A	4.0	27.27	3	mg/1	lb./day			
hosphorus P), Total 723 14 0)	X		0.34	2.84	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Radioactivity														
) Alpha, tal		X												
) Beta, ta.		X												
l) Radium, otal		X												
l) Radium 26, Total		X												
Sulfate as SO4) 14808-79-8)	X		217	1815	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Sulfide as S)	X		LT 0.02	LT 0.17	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
n. Sulfite as SO3) 14265-45-3)	X		0.25	2.09	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
n. Surfactants	X		LT 0.1	LT 0.84	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
o. Aluminum, Total (7429-90-6)	X		LT 1	LT 8.36	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
p. Barium, Total (7440-39-3)	X		LT. 0.5	LT. 4.18	N/A	N/A	LT 0.5	LT 3.33	3	mg/1	lb./day			
q. Boron, Total (7440-42-8)		X												
r. Cobalt, Total (7440-48-4)		X												
s. Iron, Total (7439-89-6)	X		0.22	1.31	N/A	N/A	0.14	0.91	3	mg/1	lb./day			
t. Magnesium, Total (7439-95-4)	X		45	376.38	N/A	N/A	N/A	N/A	1	mg/1.	lb./day	40.5 mg/1* 34.2 mg/1**		
u. Molybdenum, Total (7439-98-7)		X												
v. Manganese, Total (7439-96-5)	X		0.05	0.42	N/A	N/A	0.05	0.33	3	mg/1	lb./day			
w. Tin, Total (7440-31-5)		X												

INTINUED FROM PAGE 3 OF FORM 2-C

EPA I.D. NUMBER (copy from Item 1 of Form 1)	OUTFALL NUMBER
ILD005467667	001

Form Approved
OMB No. 2040-0086
Approval expires 7-31-88

'ART C - If you are a primary industry and this outfall contains process wastewater, refer to Table 2c-2 in the instructions to determine which of the GC/MS fractions you must test for. Mark "X" in colur 2-a for all such GC/MS fractions that apply to your industry and for ALL toxic metals, cyanides, and total phenols. If you are not required to mark column 2-a (*secondary industries, nonproce wastewater outfalls, and nonrequired GC/MS fractions*), mark "X" in column 2-b for each pollutant you know or have reason to believe is present. Mark "X" in column 2-c for each pollutant y believe is absent. If you mark column 2a for any pollutant, you must provide the results of at least one analysis for that pollutant. If you mark column 2b for any pollutant, you must provide the resu of at least one analysis for that pollutant if you know or have reason to believe it will be discharged in concentrations of 10 ppb or greater. If you mark column 2b for acrolein, acrylonitrile, 2 dinitrophenol, or 2-methyl-4, 6 dinitrophenol, you must provide the results of at least one analysis for each of these pollutants which you know or have reason to believe that you discharge concentrations of 100 ppb or greater. Otherwise, for pollutants for which you mark column 2b, you must either submit at least one analysis or briefly describe the reasons the pollutant is expected be discharged. Note that there are 7 pages to this part; please review each carefully. Complete one table (*all 7 pages*) for each outfall. See instructions for additional details and requiremen

. POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE (optiona		
	a. TESTING RE-QUIR-ED	b. BE-LIEVED PRE-SENT	c. BE-LIEVED AB-SENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANAL-YSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCEN-TRATION	(2) MASS	
IETALS, CYANIDE, AND TOTAL PHENOLS															
M. Antimony, otal (7440-36-0)	X			LT 0.5	LT 4.18	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
M. Arsenic, Total 7440-38-2)	X			LT 0.003	LT 0.025	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
M. Beryllium, otal, 7440-41-7)	X			LT 0.1	LT 0.84	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
M. Cadmium, otal (7440-43-9)	X			LT 0.05	LT 0.42	N/A	N/A	LT 0.05	LT 0.33	3	mg/1	lb./day			
M. Chromium, otal (7440-47-3)	X			0.20	1.95	0.11	0.95	0.10	0.74	104	mg/1	lb./day			
M. Copper, Total 440-50-8)	X			LT 0.10	LT 0.84	N/A	N/A	LT 0.10	LT 0.67	3	mg/1	lb./day			
M. Lead, Total 7439-92-1)	X			LT 0.10	LT 0.67	N/A	N/A	LT 0.08	LT 0.57	3	mg/1	lb./day			
M. Mercury, Total 7439-97-6)	X			0.0007	0.0058	N/A	N/A	0.0003	0.0024	3	mg/1	lb./day			
M. Nickel, Total 7440-02-0)	X			LT 0.10	LT 0.84	N/A	N/A	LT 0.10	LT 0.67	3	mg/1	lb./day			
0M. Selenium, otal (7782-49-2)	X			LT 0.02	LT 0.11	N/A	N/A	LT 0.013	LT 0.08	3	mg/1	lb./day			
1M. Silver, Total 7440-22-4)	X			LT 0.05	LT 0.42	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
2M. Thallium, otal (7440-28-0)	X			LT 0.5	LT 4.18	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
3M. Zinc, Total 7440-66-6)	X			0.08	0.98	0.06	0.48	0.05	0.40	104	mg/1	lb./day			
4M. Cyanide, otal (57-12-5)	X			0.045	0.376	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
5M. Phenols, otal	X			0.017	0.10	N/A	N/A	0.008	0.05	3	mg/1	lb./day			
IOXIN															
,3,7,8 Tetra hlorodibenzo P ioxin (1764-01-6)				DESCRIBE RESULTS N/A											

INUED FROM THE FRONT

LLUTANT ND CAS UMBER (available)	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. TEST-ING RE-QUIR-ED	b. BE-LIEVED PRES-ENT	c. BE-LIEVED AB-SENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANAL-YSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. O ANAL-YSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCEN-TRATION	(2) MASS	
S FRACTION — VOLATILE COMPOUNDS															
crolein 02 8)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
crylonitrile 13-1)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
enzene 13-2)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
is (Chloro- yl) Ether 88-1)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Bromoform 25-2)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Carbon achloride 23-5)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Chlorobenzene 90-7)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Chlorodi- nomethane 4 48-1)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Chloroethane 00-3)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
2-Chloro- ylvinyl Ether 0-75-8)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Chloroform 86-3)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Dichloro- momethane -27-4)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
V. Dichloro- luoromethane -71 8)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
V. 1,1-Dichloro- ane (75-34-3)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
V. 1,2-Dichloro- ane (107-06-2)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
V. 1,1-Dichloro ylene (75 35 4)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
V. 1,2 Dichloro- pane (78 87-5)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
V 1,3 Dichloro- pylene (542-75-6)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
V. Ethylbenzene 00 41-4)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
V. Methyl omide (74 83 9)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
V. Methyl															

LLUTANT (1) CAS JMBER (if available)	2 MARK 'X'			3 EFFLUENT							4 UNITS		5. INTAKE (optional)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
FRACTION – VOLATILE COMPOUNDS (continued)															
Aethylene de (75 09 2)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
1,1,2,2-Tetra- ethane 5)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Tetrachloro- ne (127 18 4)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Toluene 8-3)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
1,2-Trans- roethylene 0-5)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
1,1,1-Tri- ethane 5-6)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
1,1,2-Tri- ethane 0-5)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Trichloro- ne (79-01-6)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Trichloro- omethane 9-4)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Vinyl ide (75-01-4)	X			LT 0.001	LT 0.008	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
FRACTION – ACID COMPOUNDS															
Chlorophenol 7 8)	X			LT 0.011	LT 0.092	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
,4-Dichloro- l (120 83 2)	X			LT 0.011	LT 0.092	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
,4-Dimethyl- l (105-67-9)	X			LT 0.011	LT 0.092	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
,6-Dinitro-O- l (534-52 1)	X			LT 0.011	LT 0.092	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
,4 Dinitro- l (51-28-5)	X			LT 0.011	LT 0.092	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Nitrophenol 5 5)	X			LT 0.011	LT 0.092	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Nitrophenol 02-7)	X			LT 0.011	LT 0.092	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Chloro M- l (59 50-7)	X			LT 0.011	LT 0.092	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
entachloro- l (87 86 5)	X			LT 0.011	LT 0.092	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Phenol 95 2)	X			LT 0.011	LT 0.092	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
2 4 6 Tri															

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'OLLUTANT AND CAS NUMBER (if available)	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. testing required	b. believed present	c. believed absent	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. ANA YSE
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
MS FRACTION — BASE/NEUTRAL COMPOUNDS															
Acenaphthene 32 9)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Acenaphtylene 8 96-8)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Anthracene 0-12-7)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Benzidine 2-87-5)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Benzo (a) thracene 5-55-3)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
. Benzo (a) rene (50-32-8)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
1. 3,4 Benzo-oranthene 05 99 2)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
1. Benzo (ghi) rylene 91 24 2)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
1. Benzo (k) uoranthene 07 08 9)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
0B. Bis (2-Chloro-hoxy) Methane 11-91-1)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
1B. Bis (2-Chloro-hyl) Ether 11-44 4)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
B Bis (2-Chloroiso-opyl) Ether (102-60-1)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
3B. Bis (2-Ethyl-exyl) Phthalate 117-81-7)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
4B. 4-Bromo-henyl Phenyl ther (101-55-3)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
15B. Butyl Benzyl Phthalate (85 68 7)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
16B. 2-Chloro-naphthalene (91 58-7)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
17B. 4-Chloro-phenyl Phenyl Ether (7005-72-3)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
18B. Chrysene (218-01-9)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
19B. Dibenzo (a,h) Anthracene (53 70 3)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
20B. 1,2 Dichloro-benzene (95 50 1)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
21B. 1,3 Dichloro-															

'OLLUTANT AND CAS NUMBER (if available)	2 MARK 'X'			3. EFFLUENT							4 UNITS		5 INTAKE (optional)		
	a. [illegible]	b. BE-LIEVED PRE-SENT	c. BE-LIEVED AB-SENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d NO OF ANAL-YSES	a CONCENTRATION	b MASS	a LONG TERM AVERAGE VALUE		b NC AN YS
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
MS FRACTION — BASE/NEUTRAL COMPOUNDS (continued)															
1. 1,4 Dichloro izene (106-46-7	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
B. 3,3'-Dichloro izidine 94-1)	X			LT 0,008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
B Diethyl thalate 68 2)	X			LT 0,008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
B. Dimethyl thalate 31-11-3)	X			LT 0,008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
B. Di N-Butyl thalate 4 74 2)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1 .	lb./day			
B. 2,4-Dinitro-uene (121-14-2)	X			LT 0,008	LT 0,067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
B. 2,6-Dinitro-luene (606-20-2)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
B. Di N-Octyl thalate 17-84-0)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
B. 1,2-Diphenyl-drazine (as Azo-izene) (122-66-7	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
B. Fluoranthene 06-44-0)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
B. Fluorene 6-73-7)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
Hexachlorobenzene 8-74-1)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
B. Hexa-lorobutadiene 7-68-3)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
B. Hexachloro-clopentadiene 7-47-4)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
B. Hexachloro-hane (67-72-1)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
7B. Indeno ,2,3 cd) Pyrene 93-39-5)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
3B. Isophorone 78-59-1)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
9B. Naphthalene 1-20-3)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
0B Nitrobenzene 8 95 3)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
1B. N-Nitro-odimethylamine 2-75 9)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			
2B N Nitrosodi-Propylamine	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	lb./day			

IUED FROM THE FRONT

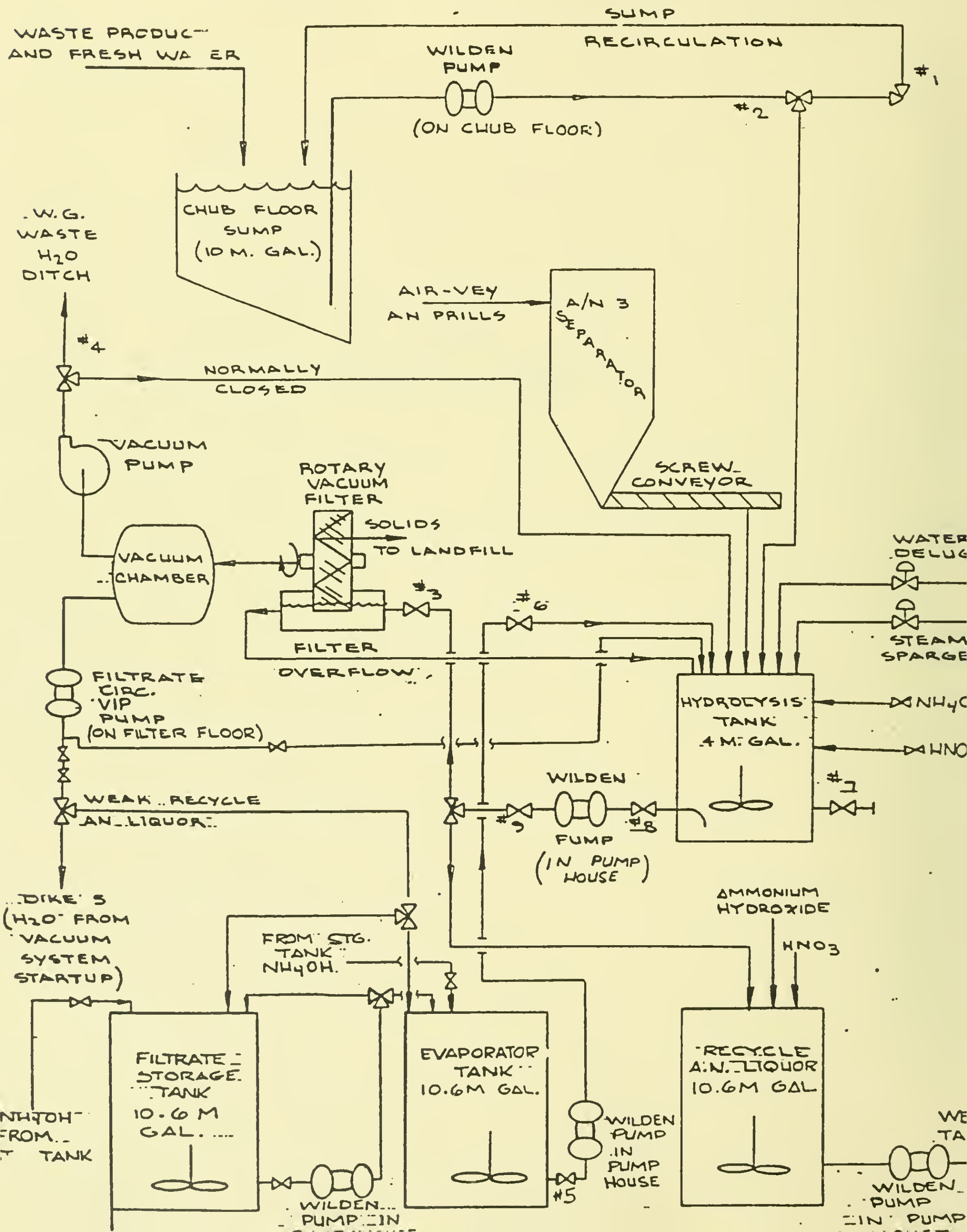
.LUTANT D CAS MBER vailable)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. testing required	b. believed present	c. believed absent	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
FRACTION – BASE/NEUTRAL COMPOUNDS (continued)															
Nitro- nylamine 5)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	1b./day			
enanthrene 1)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	1b./day			
rene -0)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	1b./day			
2,4-Tri- enzene 1)	X			LT 0.008	LT 0.067	N/A	N/A	N/A	N/A	1	mg/1	1b./day			
FRACTION – PESTICIDES															
in -2)			X												
HC 6)			X												
HC 7)			X												
HC 9)			X												
HC 8)			X												
ordane 4)			X												
-DDT 3)			X												
DDE 9)			X												
DDD 8)			X												
eldrin 1)			X												
Endosulfan -7)			X												
Endosulfan -7)			X												
ndosulfan 7 8)			X												
drin 8)			X												
drin le 3 4)			X												

AND CAS NUMBER (if available)	a. TEST-ING RE-QUIRED	b. BE-LIEVED PRE-SENT	c. BE-LIEVED AB-SENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b NO AN YS
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
MS FRACTION — PESTICIDES *(continued)*															
. Heptachlor eide 24 57-3)			X												
PCB-1242 469-21-9)			X												
. PCB-1254 097 69-1)			X												
. PCB-1221 104-28-2)			X												
. PCB-1232 141-16-5)			X												
. PCB-1248 672 29-6)			X												
. PCB-1260 096-82-5)			X												
. PCB-1016 674-11-2)			X												
. Toxaphene 01-35-2)			X												

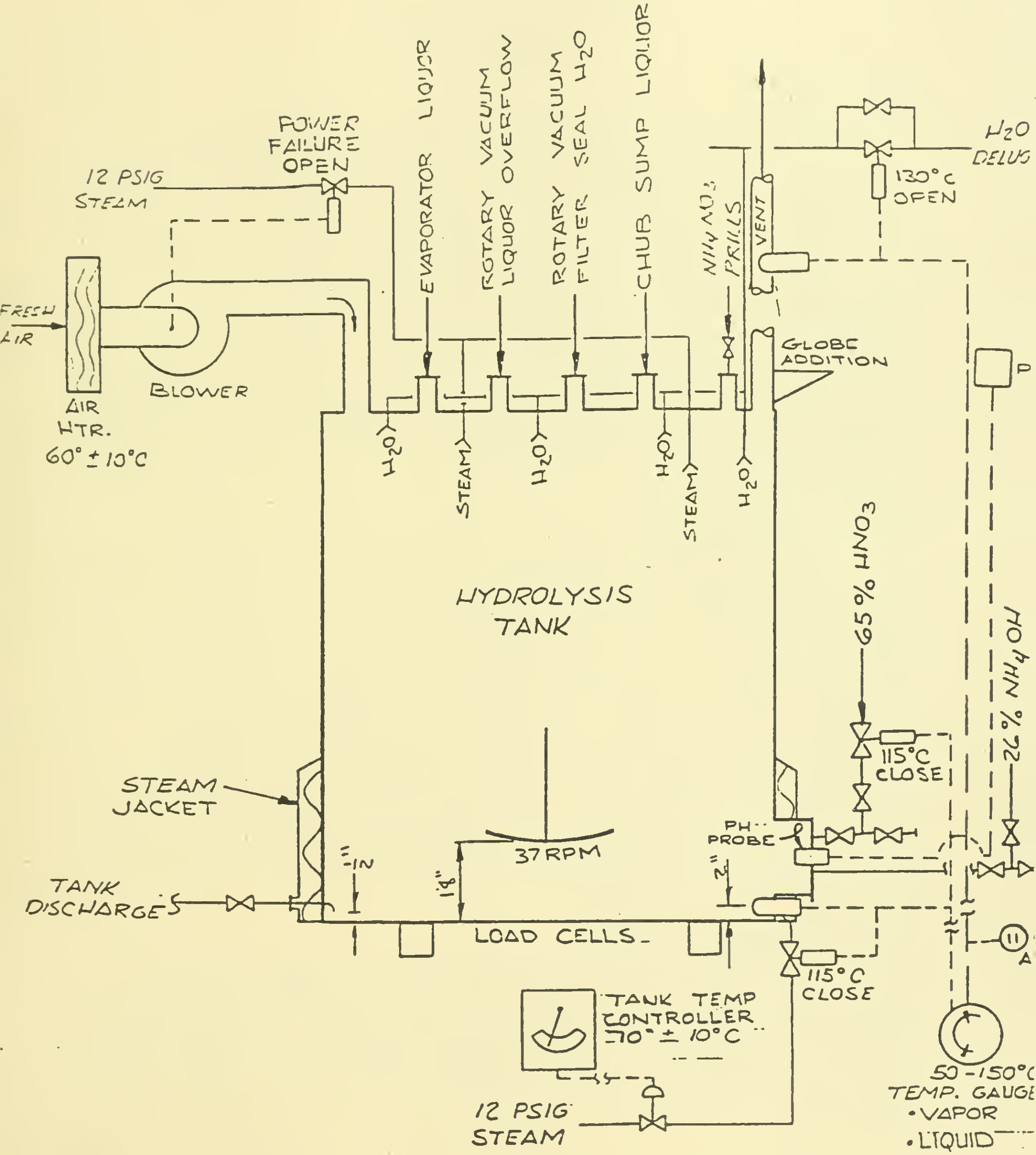
APPENDIX

Water Gel Hydrolysis Process

WATER GEL WASTE RECYCLE OPERATION



HYDROLYSIS TANK W/ SERVICES



MAXIMUM CAPACITY - 45 M lb. (5000 lb/FOOT OF LEVEL)

NOMINAL BATCH - 25-30 M lb.

HYDROLYSIS TANK

Equipment:

The hydrolysis tank is an externally heated and agitated, 37 rpm, vessel. Steam heated air is passed through the tank, over the liquid surface, to remove hydrogen and provide some evaporation. The exhaust duct contains an interlock which activates a live steam sparge into the air space of the tank if the air flow stops, to eliminate the possibility of forming a flammable mixture of hydrogen and air during the hydrolysis step. The tank is fitted with automatic temperature and operator-activated pH control. It also has an AN prills addition capability for use when bringing the salt contents to 75%. The tank exhaust stack is fitted with an air space high temperature interlock which alarms and stops acid feed at 85°C and starts a water deluge at 95°C. Tests have shown that the steam sparger will not activate the water deluge, even with the exhaust fan turned off.

Hydrolysis Operation:

Aqueous waste material is pumped into the tank from the sump, using a Wilden pump. The salt concentration is determined by specific gravity and the maximum salt concentration in the system is 16 1/2%. Water must be added, if necessary, to maintain the concentration below this level. The agitator is started and steam is turned on to the jacket to heat the tank contents. The air blower is turned on, and nitric acid is added to bring the liquid pH to 1-2 pH units. The contents are digested with agitation until all aluminum has reacted as indicated by a stabilized pH reading. The liquid temperature reaches as high as 110°C. After digestion, the tank contents are pumped using a Wilden pump, to the rotary vacuum filter. The tank contents are not allowed to drop below the agitator until essentially all suspended solids have been removed by putting the filter system on recycle.

Recycle Liquor Production:

The 90°C, 50-60% salt solution is pumped from the evaporation tank into the hydrolysis tank, using a Wilden pump. The agitator is turned on and the tank contents are maintained at 80-90°C while A.N. Prills are added to bring the total salt concentration to 75%. The resultant recycle A.N. liquor is then pumped to the recycle A.N. liquor storage tank, using a Wilden pump.

ROTARY VACUUM FILTER

Equipment:

The equipment consists of a rotary vacuum filter. Vacuum is applied by a centrifugal mechanical pump. The feed pump is fitted with a pH interlock to stop the feed if the pH exceeds 7.0.

Operation:

The filter sump is filled with a celite-water slurry and the filter agitator is started, to keep the solids evenly dispersed. The filter is started up and a filter cake applied to the polypropylene cloth on the drum. After the cake is applied, filtrate is added to the filter sump, from the hydrolysis tank, and the filtrate circulation pump is started. The solids and some celite are removed from the drum by a doctor blade. The solids are collected in fiberboard boxes, no more than 1 filled box is allowed in the area at a time. While in the area the solids in the boxes must be monitored for temperature to assure that no exothermic reaction is occurring. The boxes are disposed of by burial in the contaminated waste landfill. The filtrate is pumped to the evaporation tank using a VIP diaphragm pump.

EVAPORATION TANK

Equipment:

The evaporation tank is an externally heated, agitated tank with automatic temperature control. Preheated air is passed through the tank, over the liquid level, to provide evaporation.

Operation:

Filtered, hydrolyzed salt solution is continuously fed to the agitated tank when the rotary vacuum filter is in operation, except when the hydrolysis tank content drops to 10M lbs. at which time the hydrolysis tank/filter system is put on recycle with the filtrate being returned to the hydrolysis tank. The recycle phase is continued until the suspended solids have been removed from the hydrolysis tank solution, eliminating the possibility of a surface cake formation when the tank contents drop below the agitator level. The tank contents are maintained at 10M lbs. during this phase by addition of water to the tank, as required. When the suspended solids have been removed from the hydrolysis tank solution, the filtrate is returned to the evaporation tank, until the hydrolysis tank has been emptied. In the evaporation tank, water is evaporated from the hydrolyzed/filtered waste evaporated to bring the salt concentration to 60% maximum. The evaporation tank contents are maintained at 90°C. The pH of the solution in the evaporation tank solution is maintained at 4.0-4.5 with manual addition of 26% ammonium hydroxide. The salt solution is pumped to the hydrolysis tank using a Wilden pump.

RECYCLE AN LIQUOR STORAGE TANK

Equipment:

The recycle A.N. liquor storage tank is an internally heated, agitated fiberglass tank. Temperature is automatically controlled at 80-86°C and pH is manually controlled at 4.25-4.75 by the operator. The system is fitted with a recirculation line to enable constant recirculation of the contents.

Procedure:

Recycle AN liquor is pumped to this tank from the hydrolysis tank, using a Wilden pump. The pH is manually adjusted to 4.5±.25 pH units by the operator adding nitric acid or aqueous ammonia as required and the temperature is automatically controlled at 80-86°C. The liquor is pumped, on demand, to the liquor weigh tank inside the mix pack building, using a Wilden pump.

CHUB FLOOR SUMP

Equipment:

The sump is Cor-Ockem containing concrete catch basin under the chub floor. Metal grating is fitted over the top to enable personnel to walk over the sump and not keep water or gel from dropping into it. The sump contents are pumped through a recirculation system or to the hydrolysis tank using a Wilden pump. Because of the presence of elemental aluminum, the generation of small quantities of hydrogen can occur. Because of the pH of the solution and the large air volume above the sump, insufficient quantities of hydrogen are generated to cause explosive concentrations in the building.

Procedure:

Washdown water from the mix pack and chub areas and waste water gel from equipment cleaning are collected in the sump. Normal total salt concentration is less than 10% and the normal pH is 4.0-5.5. The maximum allowable salt concentration is 16% and water must be added to the sump, if required, to maintain the concentration below 16%. Lab tests have shown no safety problems for salt concentrations at 21%, however the 16% maximum limit was used to provide a safety factor. Concentrations are measured each time the hydrolysis tank is charged. The material is pumped through the recirculation lines to keep the solids suspended or to the hydrolysis tank, when required.

"Off standard" finished product can be added to the hydrolysis tank only under EOC conditions until a permanent procedure is issued to cover this.

INORGANIC CHEMICAL SECTOR GLOBAL BAT STUDY
SISTER PLANT TECHNOLOGY REPORT
COAGULATION/SETTLING/FILTRATION PONDS
AT CABOT CANADA LIMITED

1.0 DESCRIPTION

The wastewater treatment system at Cabot Canada Limited in Sarnia treats both process and storm water, and consists of a coagulant addition system followed by solids settling and filtration in a series of ponds. Further description of the system and wastewater sources can be found in the Ontario Site Visit Report for this plant. This treatment system provides adequate control of suspended solids, which consist almost entirely of carbon black fines. For these reasons, Cabot has been identified as a sister plant to the other carbon black plant in the sector, Columbian Chemicals Canada Limited in Hamilton, which currently discharges storm water virtually untreated.

At Cabot, wastewater is collected in a storage tank at a pumping station. Two level-controlled pumps operate alternately, and deliver wastewater to one of two downstream settling ponds. When one of these effluent pumps is running, an automated coagulant addition system is activated, and the coagulant is added to the discharge side of the wastewater storage tank. Mixing occurs in the pipe which leads to the settling ponds.

The specific coagulant used at Cabot remains confidential, as requested by the plant. Coagulation is commonly used to improve solids removal in settling by causing particle aggregation through chemical addition.

The coagulant addition system at Cabot consists of the following components:

- Mixing tank for coagulant including water supply, coagulant dump chute, mechanical mixer and steam coil heater to prevent freezing.
- Automated metering pump at the mixing tank discharge which is activated whenever the effluent pump is running.
- Associated piping, fittings and instrumentation.

The settling/filtration pond system is depicted schematically in Figure 1. Wastewater is directed to one of two settling ponds through the use of a distribution trough. Overflow from settling is fed to a filtration pond. In the filtration pond, wastewater drains by gravity through a sand bed before it is collected in perforated, corrugated steel pipe underdrains placed a 1 m intervals at the base of the pond. Filtered wastewater is collected in a level control discharge chamber where it passes over a fixed weir prior to discharge.

Settled solids accumulate in the bottom of the settling ponds. Since two ponds operate in parallel for both the settling and filtration systems, one pond may be cleaned out while the other is in use. Each pond is used for approximately six months before cleaning. Solids accumulated in the settling ponds are removed by a vacuum truck and placed in sludge drying ponds. Sand from the filtration ponds which has been fouled by suspended solids is also removed by vacuum truck and disposed in the sludge drying ponds. Once dry, solids are disposed off-site in a secure industrial waste landfill.

2.0 ONTARIO APPLICATION

This technology is being considered for application at Columbian Chemicals Canada Limited, for the treatment of two storm water streams currently discharged without treatment.

3.0 GENERAL APPLICABILITY

Widespread use of coagulation/settling has been reported in many industrial sectors, including:

- Pharmaceutical manufacturing
- Iron and steel
- Organic chemicals
- Metal mining and refining
- Petroleum refining
- Pulp and paper

Limited use also occurs in the inorganic chemical sector (U.S. EPA, 1981).

The use of coagulation enhances settling where small particles would not otherwise aggregate into particles large enough to settle. Its application is not limited to particular influent TSS concentration ranges, but rather depends on the selection of an appropriate coagulant and dosage rate for the type of solids present.

Granular media filtration has been successfully applied in a wide range of industrial sectors (U.S. EPA, 1981), including:

- Inorganic chemicals
- Iron and steel
- Metal casting
- Pharmaceutical manufacturing
- Petroleum refining
- Metal finishing
- Metal mining and refining
- Pulp and paper

Filtration technologies are generally applicable to streams containing less than 100 mg/L of total suspended solids but will not be effective on streams containing less than 5 mg/L. In addition, oil and grease levels above 35 mg/L may require pretreatment to avoid fouling of the filtration media (U.S. EPA, 1981). In the case of Cabot, coagulation and settling act as pretreatment to the filters.

4.0 DESIGN INFORMATION

Coagulation

Type of coagulant and dosage rate will need to be determined through the use of jar tests. There are no readily applicable theoretical or typical values which may be used for design purposes. The coagulant and dosage used at Cabot is confidential.

Settling

Typical surface loading rates for settling following coagulant addition range from 20 to 65 m/d, depending on the type of coagulant used (U.S. EPA, 1981). Since the sidewalls of the settling ponds at Cabot are sloped, surface area varies with depth of water in the pond. The level control discharge chamber maintains a minimum depth of 0.71 m in the settling pond. This depth corresponds to a surface loading rate of 69 m/d, based on the flow rate of 11,300 m^3/d provided by the effluent discharge pump. This value compares favourably with the typical design values.

Filtration Ponds

The surface loading rates of 92 m/d for the ponds at Cabot are based on the discharge pump flowrate of 11,300 m^3/d and the surface area of the sand medium 122 m^2. This value compares favourably with typical design values of 100 to 300 m/d (U.S. EPA, 1981) for rapid sand filters.

Land Requirements

Total land area for the twin settling/filtration pond system at Cabot is 3,350 m^2. This was based on the area used by the ponds and pond berms. The berms have the following features:

- 2:1 slope.
- 3.0 m depth in settling ponds, therefore berms are 12.3 m wide, including a 0.3 m width at the crest.

- 2.6 m depth in filtration ponds, therefore berms are 10.7 m wide, including a 0.3 m width at the crest.

- The distribution trough, overflow manholes and discharge chamber are contained within the confines of the berms.

The land area used for the sludge drying pond is 1,300 m^2.

The annual amount of sludge generated for disposal in the sludge drying ponds is estimated at 900 m^3. This estimate is based on the following assumptions:

- Annual total flow of 760,000 m^3 through the treatment plant calculated from mean flow rate measured over the 12 months of MISA monitoring.

- Solids are generated from three sources in the treatment system:

    - Settled solids (assume 90% removal efficiency and 5 mg/L of TSS discharged), yielding approximately 35 t.

    - Settled coagulant, yielding 30 t.

    - Fouled filtration sand, yielding 20 t.

- Sludge placed in the ponds at 10% solids.

This amount of sludge occupies a depth of approximately 0.7 m in the pond. Any depth less than 1 m will be suitable for evaporative drying.

The annual amount of sludge removal from the drying pond is approximately 250 m^3. This assumes that the 900 m^3 placed is dried to 35% solids. These dried solids are disposed as a hazardous waste in a secure landfill.

5.0 PERFORMANCE

The performance of coagulation/settling and filtration systems in the treatment of industrial wastewater has been documented by the U.S. EPA (1981). Table 1 presents available data. Note that these data summarizing a range of applications and industrial sectors.

At Cabot, mean TSS effluent concentration for the MISA monitoring period was approximately 5 mg/L and the maximum value was 65 mg/L. Minimum, maximum and mean values for Priority 1 parameters at Cabot are presented in Table 2 to show the type of effluent that is achieved at Cabot. It should be noted that the treatment system targets the removal of TSS. Some incidental removal of metals and other contaminants may also result, but the extent of this removal cannot be determined, since to influent quality has not been characterized.

Table 1
Performance of Coagulation/Settling and Filtration Systems

Technology	Effluent TSS Concentrations (mg/L)		Removal Efficiencies (%)	
	Range	Median	Range	Median
Coagulation/settling	2.5 - 43	28	21 - 799	91
Filtration	<1 - 7,300	17	6 - 99	76

6.0 OPERATING REQUIREMENTS

The primary operating requirements for the coagulation/settling pond system are as follows:

- Supply of coagulant.
- Labour costs involved in maintaining a supply of coagulant solution in the mixing tank for metering to the effluent stream and in transferring sludge to the sludge drying ponds.
- Energy costs for the effluent pumping system and the automated coagulant addition system.
- Sludge removal from the settling and filtration ponds by vacuum truck and disposal costs as a hazardous waste after drying in sludge drying ponds.
- Replacement of sand in the filtration ponds.

One of the major advantages of a filtration pond system is the fact that it operates passively. All flows are gravity fed to the system and the level control discharge chamber acts to regulate the rate of filtration. The only major operating requirement of note is the cleaning described above, with replacement of sand as required.

An alternative to the use of sludge drying ponds is the use of a private contractor to haul raw, undried sludge offsite. This increases the vacuum truck operations, but eliminates the need for sludge drying beds and hazardous waste disposal.

7.0 CAPITAL COSTS

Table 3 presents a capital cost estimate for the Cabot filtration pond. The total system cost of $980,000 includes $100,000 for a monitoring station which may or may not be required in all new applications (CH2M HILL ENGINEERING LTD., 1991). The 1985 costs for this system reported by Cabot were $753,000. Using the ENR CCI (Toronto) of 6,343, this figure translates to $982,000 in 1991 dollars, and compares favourably with the estimate

Table 2 , CABOT CANADA
Summary of Flows and Priority One Pollutants
MISA Control Point: CO0100, Final effluent
Description: Filter Bed Effluent

Contaminant	Units	Concentration over 12 Month Sampling Period			Loading (kg/d)
		Minimum	Maximum	Mean	
Flow	m3/d	335	4500	2070	
COD	mg/L	13	23	18	51.338
Cyanide	mg/L	0.001	0.037	0.004	0.008
Total Kjeldahl Nitrogen	mg/L	0.16	1.6	0.51	0.937
Nitrate & nitrite	mg/L	0.025	1.1	0.605	1.123
DOC	mg/L	0.8	13	3.05	5.956
Specific Conductance	us/cm	260	6100	750	
Total Suspended Solids	mg/L	4.2	65	4.87	10.283
Aluminum	ug/L	190	1600	661	1.391
Copper	ug/L	4	48	23.5	0.051
Strontium	ug/L	2	300	169	0.349
Zinc	ug/L	4	510	73.6	0.135
Sulphide	ug/L	30	30	30	0.096
Oil and Grease	mg/L	0.96	10	1.24	2.475
Chloride, Unfiltered Reactive	mg/L	14	430	127	213.352
Sulphate, Unfiltered Reactive	mg/L	41	65	53	154.518

presented in Table 3. It should be noted that unit costs are provided for most items in Table 3, but that a number of site-specific items have been taken into account as contingencies, including:

- Wastewater collection piping.
- Effluent outfall piping.
- Roadways (Costs for a 3 m wide roadway between the ponds are provided; additional roadway access may be required.).
- Any buildings required for storage, etc.
- Utilities such as water and electricity if required.

It should be noted that a sludge drying pond is also used at the Cabot site. Capital costs for this pond were unavailable from Cabot, but can be estimated at $172,000 based on the 1,300 m^2 area and berms providing 1 m depth in the pond. The alternative to this capital cost is the disposal of pond sludge without drying, as described in Section 6.

8.0 OPERATING COSTS

Table 4 summarizes available information on operating costs for the coagulation/settling/filtration system.

Table 4
Operating Costs for the Coagulation/Settling/Filtration System

Item	Basis	Annual Operating Cost ($1990)
Coagulant supply	• as reported by Cabot	1,250
Labour (including coagulant and sludge handling)	• 0.2 person-year	6,000
Vacuum Truck Operations	• as reported by Cabot	24,000
Dried Sludge Disposal	• 85 t/year of hazardous waste, consisting of settled solids, coagulant and waste sand, at 35% solids, disposed for $350/t	85,000
Energy	• as reported by Cabot	3,000
Sand Replacement	• 10% of total volume replaced per year at $20/t	300
TOTAL	• rounded to nearest hundreds	**119,500**

References:

- Lu, 1991.
- Pizans, 1991.

Table 3
CAPITAL COSTS FOR FILTRATION PONDS (1), (2)

	UNIT	UNIT COST	QUANTITY	NOTES	COST
Coagulant addition system	lump sum	-	-		$80,100
- Mix tank with mechanical mixer, coagulant dump chute and steam coil heater					
- Metering pump					
- Control panel and associated instruments					
- Associated piping and fittings					
Distribution trough	lump sum	-	-		$30,000
Site Work					
- Clear and grub	lump sum	-	-		$25,000
- Strip and stockpile existing topsoil (30 cm depth)	m^3	$4	1005	(3)	$4,020
- Excavate and place (1.0 m depth, 1.5 m below filtration area)	m^3	$9	3470	(5)	$31,230
- Haul and place clay for lining (allow 8 km haul) (1.0 m depth)	m^3	$13	3350	(4)	$43,550
- Haul and place clay for berms (allow 8 km haul)	m^3	$13	4230	(4)	$54,990
- Supply and place rip-rap erosion protection and geotextile on berms	m^2	$50	2970	(7)	$148,500
Filtration ponds					
- Supply and place geotextile above and below clear stone gravel	m^2	$32	488	(5)	$15,616
- Supply and compact clear stone gravel (45 cm depth)	m^3	$16	106	(5)	$1,689
- Supply and install perforated corrugated steel pipe (15 cm diam, 1 m spacing)	m	$50	342	(6)	$17,100
- Supply and compact filtration media (sand) (45 cm depth)	m^3	$20	110	(5)	$2,196
Piping					
- Supply and place piping for distribution trough (45 cm diam.)	m	$300	20		$6,000
- Supply and place concrete piping and manholes for 4 overflows to filtration ponds	lump sum	-	-		$48,000
- Supply and place concrete discharge pipe (45 cm diam.) to outside edge of berm	m	$300	15		$4,500
Level control discharge chamber	lump sum	-	-		$15,000
- Supply and place monitoring equipment ✓	lump sum	-	-		$100,000
Roadway between settling and filtration ponds					
- Granular A (15 cm depth)	m^3	$13	25		$319
- Granular B (45 cm depth)	m^3	$11	76		$827
Fencing (2.5 m buffer around ponds)	m	$44	224	(3)	$9,856
Topsoil, finish grade, seed and mulch	m^2	$3	2040	(8)	$6,120
SUBTOTAL					$644,614
Contractor insurance, bonds and mobilization at 7%	-	-	-	-	$45,123
Construction and estimate contingency at 20%	-	-	-	-	$128,923
Engineering contingency at 25%	-	-	-	-	$161,153
TOTAL (rounded to nearest 000's)					$980,000

NOTES:

(1) This estimate includes the following site specific items as contingencies only:
- Wastewater collection piping.
- Effluent outfall piping.
- Roadways required to access ponds (roadway between ponds provided).
- Any buildings required for storage, etc.
- Utilities such as water and electricity if required.

(2) ENR CCI (Toronto) at 6343.
(3) Based on total construction area.
(4) Based on total volume of berms. Assumes that material excavated is not used in berm construction.
(5) Based on total filtration area of both filtration ponds.
(6) Based on dimensions of both filtration ponds.
(7) Based on surface area of berms.
(8) Based on area of 2.5 m buffer and outside slope of berms.

If a private hauler were used to remove raw, undried sludge in order to avoid the use of sludge drying ponds, annual costs would be \$310,000 (based on \$320/m^2 plus \$127/hour transportation fee) (A & A Liquid Waste Removal Company, 1991), for total annual operating costs of \$320,500.

9.0 REFERENCES

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APPENDIX

Figure

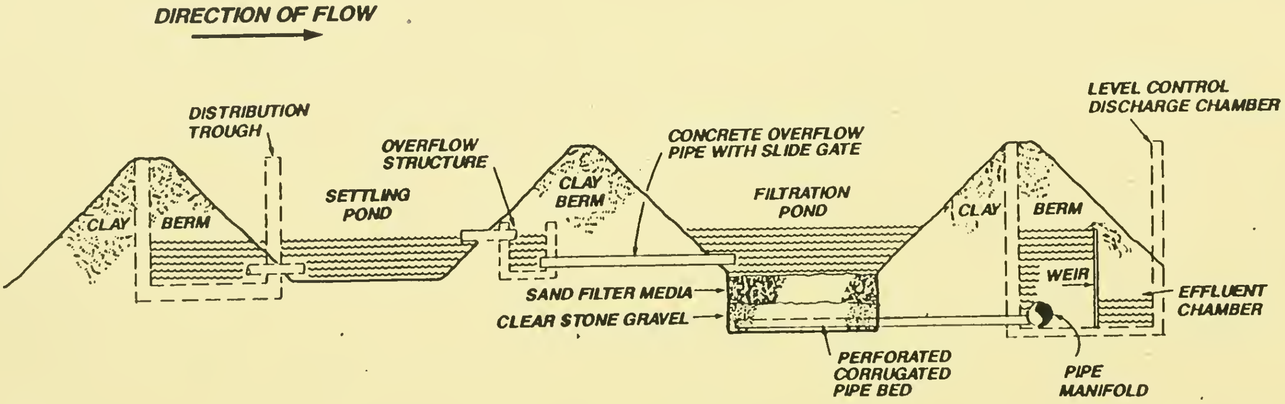

Figure A1

COAGULATION/SETTLING/FILTRATION PONDS

CROSS SECTIONAL VIEW

(not to scale)

INORGANIC CHEMICAL SECTOR GLOBAL BAT STUDY
SISTER PLANT - GLOBAL SITE VISIT REPORT
ALLIED SIGNAL INC. BATON ROUGE SOUTH WORKS

1.0 PLANT SITE

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Engineered Materials Sector
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Date of Visit: September 4, 1991

2.0 PLANT DESCRIPTION

The Baton Rouge South Works is Allied Signal's largest fluorocarbon plant. The facility is located in Baton Rouge, Louisiana on the east bank of the Mississippi River.

The Baton rouge South Works contains three production units for the manufacture of Genetron^R Fluorocarbons 22, 113/114, and 1113. In addition, Genetron byproduct hydrochloric acid (HCl) is reacted with limestone rock to produce another Baton Rouge South Works product calcium chloride. Genetron products are packed in returnable and non-returnable containers for sale in the refrigeration wholesale market. Calcium chloride is transported by tank truck, rail car, and barge from a company owned dock at another location.

2.1 Plant History

The Baton Rouge South Works began in 1945 with a four furnace hydrofluoric acid operation. This plant was subsequently expanded to six furnace operations before its shutdown in 1983.

In 1948, the first Genetron facility (G-152a) was started, followed one month later by Genetron 142b. In 1950, the Baton Rouge Development laboratory was established. This facility functioned until 1966, and was the major development facility for a series of fluorine based compounds. These included Compound A, oxygen difluoride, tungsten hexafluoride, uranium hexafluoride, hexachloroacetone, hexafluoroketone, Genetron 13 and 23, and tungsten granules. These products were manufactured at the plant during the period 1957-1972.

In 1953, sulphur hexafluoride, chlorine trifluoride, bromine trifluoride, and liquid fluorine were first produced at these Works. These facilities are no longer in operation.

The first major Genetron operation began with the production of Genetron 11 and 12 in 1952. In 1954, the startup of a new sulphuric acid plant at this site made this operation a fully integrated chemical operation. The Baton Rouge South Works no longer produces sulphuric acid. Allied Signal's only G-113/114 and G-1113 units also began operation during 1954. Genetron 22, which had previously been manufactured in the G-12/11 equipment, now began production in its own unit.

The VK Polymer operation was integrated into Baton Rouge South Works in 1961 and remained until 1972 when it transferred to Elizabeth Works.

Baton Rouge South Works has produced a large number of specialized fluorine based chemicals in its history. Most of these chemicals have been discontinued, and for production of many of these, large scale commercial facilities were created at Metropolis, Illinois.

The calcium chloride production unit began operations in 1981 using byproduct hydrochloric acid and limestone rock as raw materials.

The facility currently has approximately 160 full-time employees.

2.2 Product Description

Genetron 22, chlorodifluoromethane ($CHClF_2$) is utilized in reciprocating compressors for package-type air conditioners, home freezers, and industrial processes requiring a lower-temperature refrigerant. Most home air conditioners would use this refrigerant.

Genetron 113, trichlorotrifluoroethane ($C_2Cl_3F_3$) is used in low capacity centrifugal chiller packaged units. It operates best in units with very low system pressures and high gas volumes. An additional high volume use of this material is as a cleaning agent and degreaser in the electronics industry.

Genetron 114, dichlorotetrafluoroethane ($C_2Cl_2F_4$) blended with other Genetron materials is used as a propellant system for pharmaceutical products. The principal application is in centrifugal compressors for high capacities or for lower evaporator temperature process-type applications.

Genetron 1113, trifluorochloroethylene ($CClF=CF_2$) is primarily used in the manufacture of high polymer thermoplastics. It can be used to polymerize low molecular weight greases, oils, and waxes to product high performance lubricants and hydraulic fluids.

Calcium chloride ($CaCl_2$) solutions produced at the plant are used in the oil industry as completion fluids, packer fluids, and work-over fluids as well as a drill bit lubricant.

2.3 Process Descriptions

The continuous process used in each production unit is similar although the starting raw materials are somewhat different.

In the case of G-22, chloroform is reacted with hydrofluoric acid in the presence of an antimony catalyst system. Chlorine is introduced into the reactor to shift the equilibrium forward more of the deused product. In each instance hydrochloric acid is produced in the reaction. The hydrochloric acid is scrubbed from the gas stream using water. At Baton Rouge the muriatic absorbers are operated to produce acid levels of 32 to 33 percent that will result in the desired 38 percent calcium chloride solution when reacted with limestone. The gas stream is further scrubbed using caustic scrubbers prior to its release.

The liquid product is removed by distillation and is purified by further distillation steps as necessary. Reacted raw material is recycled to the reactor.

The G-113 and G-114 products utilize dichloroethane as raw material with the process very similar to the G-22 process. Additional distillation steps are necessary to separate the G-113 and G-114 which are co-produced in the same reactor.

G-1113 starts with methanol as a raw material and utilizes a zinc catalyst system in the reactor.

Calcium chloride solution is produced by reacting the hydrochloric acid recovered from the Genetron process gas treatment system with limestone in fixed bed reactors. Raw limestone is fed to four reactors operating in parallel. The hydrochloric acid also enters at the top of the reactor and flows down through the bed of limestone. The calcium chloride solution is drawn off the bottom of the reactors and is clarified before being stored in tanks prior to shipment.

3.0 WASTEWATER MANAGEMENT SYSTEM

The facility has two separate wastewater systems serving the plant area, along with a sanitary drain connected to the Baton Rouge municipal system. Figure A.1 of Appendix provides a block diagram with wastewater flows indicated.

3.1 Non-Process Sewers

Rain water from roadways and non-active areas is collected along with non-contact cooling water, air conditioner water, and blowdown from steam boilers. This water flows directly to the Mississippi River. The pH of this system is continuously monitored and if the pH leaves the 6 to 9 range, an alarm is sounded and the flow from this system can be diverted to the process wastewater treatment system. A system of pH monitors is dispersed throughout the collection trenches allowing an almost immediate identification of the problem areas so that corrective action can be taken quickly.

3.2 Process Water Sewer

All rain water which could be contaminated with product or raw materials is collected in a process wastewater trench. This system also receives some boiler blowdown, cooling tower blowdown, caustic scrubber blowdown, washdown from the production areas, wastewater from the Venturi scrubbers used on the calcium chloride production units, as well as batch discharges from the metal treatment system. This process sewer is routed for wastewater treatment in the Effluent Treatment Facility (ETF).

3.3 Sludge from Calcium Chloride Production

Sludge removed from the calcium chloride solution in the clarifier and filters is trucked to ponds 1 or 4 for solid storage. Any storm runoff from these pond areas is returned to the process sump for treatment.

4.0 WASTEWATER TREATMENT

4.1 General Treatment

Wastewater generated at the South Works which is or has the significant potential to be contaminated from the manufacturing operations is combined and conveyed for treatment by the process wastewater system. Figure A.2 is a process flow diagram for the wastewater treatment system.

The combined flows enter a process sump for surge buffering and pH adjustment to approximately 8.5 to 9.0 by automatically adding 25 percent caustic soda solution. The sump level is controlled by automatic valves and two (2) staggered pumps which feed a wastewater air stripper. One pump runs continuously while the other activates on increasing level. Proper pH adjustment in the sump is important for the precipitation and control of TSS and fluorides.

The packed bed air stripper removes volatile organics to trace levels before the water is pumped to one of two 2,230 m^3 holding tanks. A polymer is added as a flocculating agent. Discharges from these tanks are batch operations which go through a series of three neutralization steps using spent plant hydrochloric acid to yield a final pH of approximately 7.0 to 7.5. After neutralization, the wastewater flows to one of two ponds (surface impoundments) where the flow velocity is reduced to facilitate additional TSS removal. Finally, the wastewater is discharged via gravity through a Parshall flume and sampling station to the receiving stream.

Bulk solids settling currently occurs in the holding tanks, however, a clarifier/filter press unit has been scheduled for installation to remove the TSS from the continued wastewater before introduction to the air stripper. In addition, a third 750,000-gallon holding tank is being installed as the two ponds are being taken out of wastewater treatment service.

The present configuration results in relatively rapid fouling of the air stripper packing media due to a buildup of solids. Currently, a change of packing is needed every 90 to 100 days. The pressure drop across the stripper is monitored and when it gets in the range of 22 to 25 cm of water column the media are changed.

The first few occasions when media needed to be changed, the solid building was so advanced that the material needed to be chipped out. A change in media type and earlier media change-out have eliminated the cemementation problem. It is expected that the clarifier prior to the strippers will preclude the rapid solids build-up.

The decision to add the air stripper was based on a belief at the time that the wastewater ponds at the site would need to be permitted Hazardous Material Treatment facilities. Subsequent rule changes have turned out such that this would not have actually been the case, but it was this belief which fostered the decision to treat the water stream. The decision to go with an air stripper was made rather rapidly under considerable time pressure.

Steam stripping was not seriously considered since the volume of recoverable products or raw materials is so low.

The air stripper was estimated to result in 8.8 tonnes/yr of hydrocarbons entering the atmosphere. The discharge could reach about 45 tonnes/yr before further remedial action would be required.

Allied considered using carbon absorption on the gas stream leaving stripper but did not do so because the stripper could be permitted as is. At the time it was believed that the carbon could be returned to the supplier for monthly reprocessing without the need for hazardous materials handling.

The use of granular activated carbon as the treatment approach was rejected due to the high cost and the need to provide upstream solids removal.

A biological treatment system was also rejected since the organic loadings are too low and a supplemental microbial food sources would be required.

4.2 Metals Treatment

Metallic zinc is added to the G-1113 process reactor to produce G-1113 and zinc chloride. In this reaction zinc is not completely (100%) consumed and periodic removal of the accumulated unreacted zinc and sludges is necessary to maintain favourable process conditions. In addition, several other vessels which are utilized in the process to capture and treat zinc for further raw material usage must be periodically cleaned (zinc bearing sludge) for process optimization and control. These clean outs are done in batch operations where the bulk solids are drummed for disposal and the suspended sludge and wastewater pumped to the metals treatment tank for processing.

Antimony bearing wastewater is periodically generated by the G-22 and G-113 processes. To facilitate the desired reactions, an antimony compound is used in both system reactors as a catalyst. During process turn-arounds or times requiring vessel inspections, the antimony catalyst is transferred in bulk to holding tanks. The reactors are then flushed several times with water to remove any remaining traces of catalyst and pumped by batch operation to the metals treatment tank for processing.

Wastewater containing heavy metals (zinc and antimony) is pumped to a metals treatment tank in batch quantities. The wastewater is mixed and the pH is adjusted using 25 percent caustic soda solution to approximately a pH of 9.0 to 10.0. After the adjustment, the complex metal salts are allowed to settle and the wastewater decanted from the tank to the process sewer system.

Treatment for both metals is currently conducted in a single tank. Installation of a second metals treatment tank is underway which will allow for the segregation of the metals and more effective removal.

4.3 Recent Discharge Data

Table A.1 presents a summary of monitoring data for Baton Rouge South works during 1990. Table A.2 presents a summary of selected compounds as measured at the inlet and the outlet of the air stripper. The stripper removal efficiency under the prevailing operating conditions ranges from 42 percent to 98 percent depending upon the compound.

5.0 CAPITAL COST REPORT

Air Stripper

The air stripper was installed in 1989 as part of a project that included:

- Two above-ground tanks with a capacity of 2,840 m^3 each.
- A process sump for pH adjustment and piping system connecting the tanks, air stripper, and the ponds that provide double containment of all process flows.
- A process control room complete with a gas chromatograph unit to allow process monitoring.
- The air stripper, designed for a nominal flow of 1.5 m^3/min. It is currently fitted with pumps which limit the flow to about 3.8 m^3/min, but the stripper internals are designed for a maximum flow of about 6.4 m^3/min. The stripper uses a centrifugal blower which delivers 295 m^3/min of air at 25 cm of water column.

The overall project cost was $4,500,000 - $5,000,000 U.S.

The project to add a conical clarifier, filter press, and a third 2,840 m^3 tank is currently underway and will cost about $2,200,000, including a building for the filter press operation.

5.1 Calcium Chloride Solution Production Unit

This unit was installed in 1980 at a cost of approximately $8,000,000 - $9,000,000 U.S., and processes about 340 m^3 per day of hydrochloric acid (at 32-33% concentration).

The facility includes a bucket elevator to lift the limestone to the top of four parallel fixed bed reactors. Gas exhausted from the reactors is scrubbed with water in a venturi scrubber. The calcium chloride solution is clarified in rotary rake clarifier before being stored in tanks awaiting shipment.

The plant occupies about 0.4 hectares of which more than half is devoted to limestone storage.

6.0 AUDIT TEAM

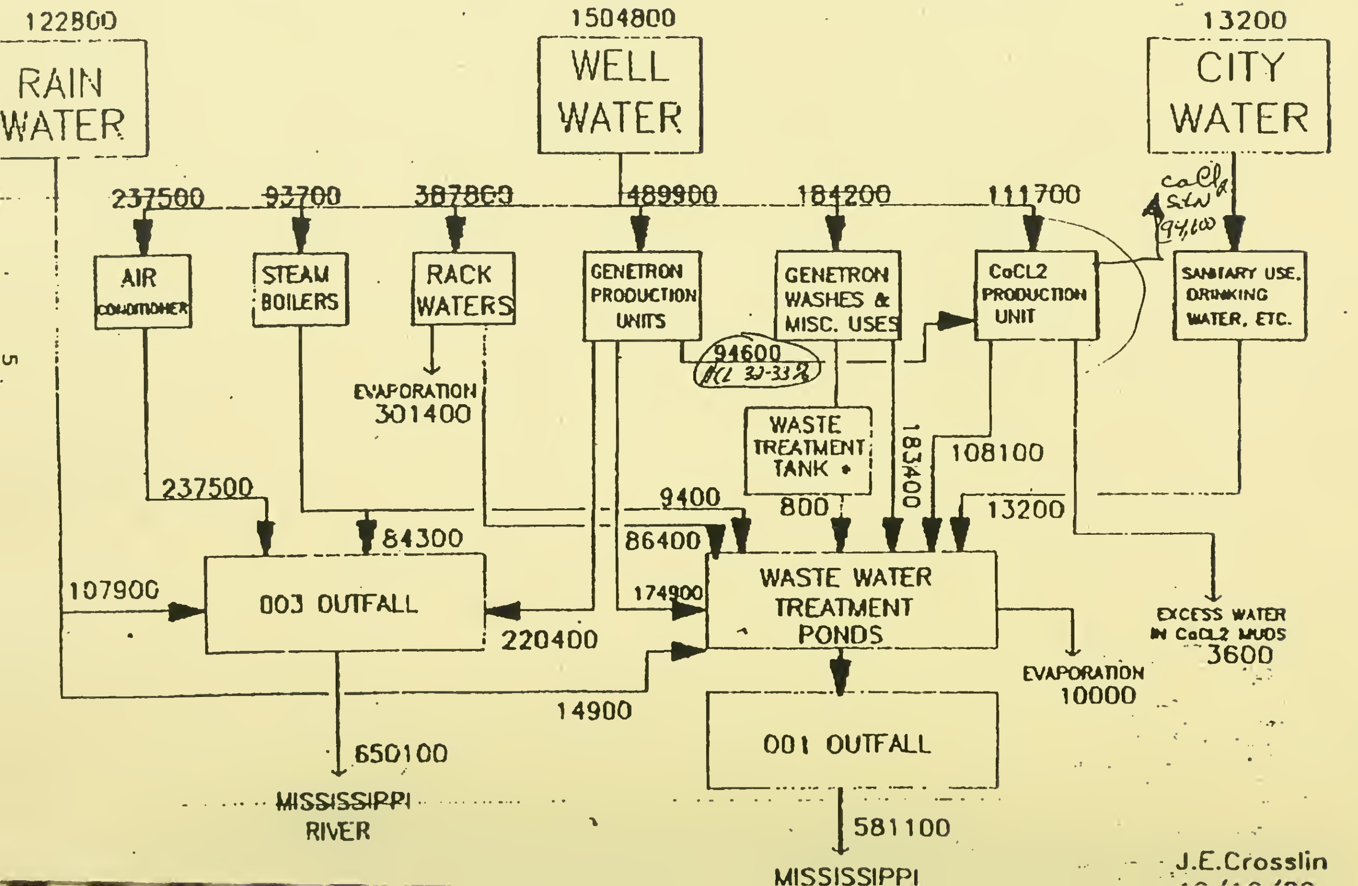
Frank A. Ryan, P.Eng., - MOE
Art Stelzig - Environmental Canada
Deborah Ross - CH2M HILL
Leo C. Ehrenreich - SAIC

APPENDIX

Figures and Tables

Figure A.1

ALLIED – SIGNAL INC.
Baton Rouge South Works
Water Flow Data (GPD) – Basis 1989 Data (as of 10/1/89)



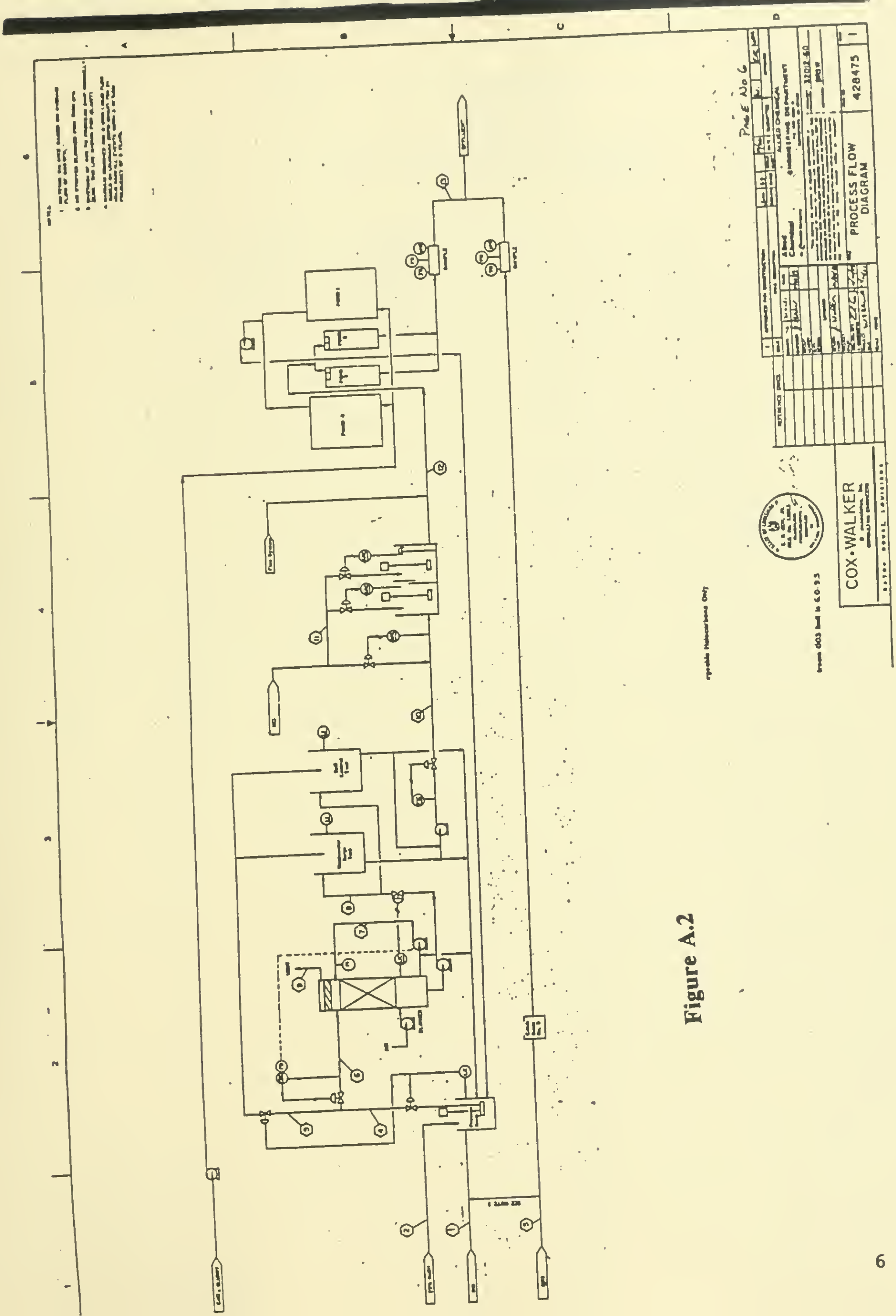

PAGE No 6
Allied Chemical
ALLIED CHEMICAL
32012-40
PROCESS FLOW DIAGRAM
428475
COX•WALKER
EFFLUENT

Figure A.2

Table A.1

ALLIED-SIGNAL INC.

BATON ROUGE SOUTH WORKS, 1990 DMR DATA

	FLOW MGD		TEMP.			TSS LBS./DAY		FLUORIDES LBS./DAY		PURGEABLE HALOCARBONS LBS./DAY		ZINC LBS./DAY	
	AVG.	MAX.	MIN.	AVG.	MAX.	AVG.	MAX.	AVG.	MAX.	AVG.	MAX.	AVG.	MAX.
PERMIT	NA	NA	NA	NA	NA	160.0	320.0	1800 180.0	270.0	5.00	10.00	6.00	11.00
MONTH													
JAN.	0.6158	0.9044	60	77	86	56.7	230.3	60.6	114.7	0.67	1.97	0.60	1.05
FEB.	0.5720	0.7856	68	78	87	80.1	170.2	51.5	86.1	0.50	1.06	0.55	1.41
MAR.	0.5514	0.7298	66	83	95	80.0	204.5	47.4	80.7	0.96	6.62	0.54	1.29
APR.	0.4787	0.5950	68	85	96	31.9	123.9	41.4	60.6	1.29	5.20	0.57	0.97
MAY	0.4460	0.5780	65	91	103	21.8	51.6	35.6	53.0	0.62	1.00	0.26	0.47
JUN.	0.4616	0.6322	88	97	105	20.5	93.1	42.0	67.6	0.93	2.47	0.38	0.60
JUL.	0.4285	0.5757	85	96	106	17.0	62.0	51.4	103.3	0.92	3.05	1.43	2.76
AUG.	0.4922	1.1000	81	96	106	38.1	110.2	45.6	90.9	1.40	6.28	5.59	11.06
SEP.	0.5222	1.0092	68	88	96	85.0	433.4	71.6	223.7	1.41	4.57	3.82	5.30
OCT.	0.5225	0.9393	66	79	92	27.3	70.0	73.8	269.9	1.38	9.72	2.06	2.63
NOV.	0.4580	0.8433	54	73	81	20.0	119.7	80.8	167.3	0.57	1.08	5.50	9.02
DEC.	0.6042	1.0002	50	77	104	32.8	126.9	67.5	102.6	1.47	6.86	5.45	7.06
AVG.	0.5126	0.8077	68	85	96	42.6	149.7	55.8	118.4	1.01	4.16	2.23	3.64

Table A.1 (Continued)

COPPER LBS./DAY		LEAD LBS./DAY		ANTIMONY LBS./DAY		NICKLE LBS./DAY		CHROMIUM LBS./DAY	
AVG.	MAX.	AVG.	MAX.	AVG.	MAX.	AVG.	MAX.	AVG.	MAX.
0.46	0.62	0.06	0.06	0.06	0.06	0.06	0.06	0.28	0.51
0.10	0.14	0.71	0.85	3.20	4.00	0.05	0.05	0.05	0.05
0.50	0.53	0.06	0.06	9.10	14.60	2.08	2.28	0.41	0.53
0.50	0.99	0.04	0.05	0.40	0.50	0.04	0.05	0.16	0.26
0.10	0.15	0.05	0.05	1.10	1.40	0.58	0.66	0.12	0.19
0.15	0.17	0.10	0.12	0.41	0.43	0.32	0.35	0.04	0.04
0.03	0.03	0.28	0.45	0.03	0.03	0.68	0.87	0.03	0.03
0.12	0.13	0.04	0.04	0.04	0.04	0.50	0.62	0.12	0.13
0.05	0.05	0.05	0.05	0.50	0.50	0.05	0.05	0.05	0.05
0.07	0.09	0.04	0.04	5.70	7.00	0.47	0.50	0.15	0.22
0.05	0.07	0.05	0.07	3.00	3.10	0.05	0.07	0.05	0.07
0.19	0.27	0.05	0.05	3.50	4.90	0.32	0.54	0.19	0.27
0.19	0.27	0.13	0.16	2.25	3.05	0.43	0.51	0.14	0.20

Table A.2

ALLIED-SIGNAL INC.

BATON ROUGE SOUTH WORKS

SUMMARY OF SELECTED COMPOUNDS AT AIR STRIPPER MONITORED
THREE TIMES PER WEEK DURING 1990

MeOH		CHCL3		F-113		CCL4		PCE		FLUORIDES
INLET	OUTLET	INLET	OUTLET	INLET	OUTLET	INLET	OUTLET	INLET	OUTLET	INLET
mg/l	mg/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	mg/l
103.70	60.00	97.80	39.80	3,296.50	63.30	3.80	1.60	52.70	6.00	12.00

Note: MeOH recovery system was installed in the production unit during late 1990. Current MeOH concentrations are approximately 30 mg/l inlet and 10 mg/l outlet.

INORGANIC CHEMICAL SECTOR GLOBAL BAT STUDY
SISTER PLANT - GLOBAL SITE VISIT REPORT
ALLIED-SIGNAL INDUSTRIAL CHEMICALS DIVISION - GEISMAR

1.0 PLANT SITE

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Date of Visit: September 5, 1991

2.0 PLANT DESCRIPTION

The Geismar Works is located approximately 25 kilometres south of Baton Rouge, Louisiana on the east bank of the Mississippi River. The Geismar Works produces both anhydrous and aqueous (70%) hydrofluoric acid up to a capacity of approximately 95 tonnes per year. Allied reports that this is the largest HF facility in the world. Aluminum fluoride is also produced at the site at a rate of up to 109 tonnes per day.

2.1 Plant History

The plant site was originally developed as an ethylene plant in 1967. The HF facility, a nitrogen fertilizer plant and phosphate fertilizer plant were developed at this 607-hectare site during the 1970's. In the mid 1980's, Allied restructured its businesses and sold the ethylene plant to UTP Corporation (Union Texas Petroleum) in 1985. The nitrogen fertilizer facility and the phosphate fertilizer facility were sold to the Acadian Corporation in 1984. The facilities are still interconnected to some extent as far as utilities are concerned for example. Allied supplies river water to the other facilities and buys steam from Acadian.

At the present time, Allied has approximately a 32-hectare active site including the fluorogypsum stacks. They have retained about 120 hectares of inactive land for potential future use.

2.2 Product Description

The primary products manufactured at this facility and details of product uses are listed in Table 2.1.

2.3 Process Description

The hydrofluoric acid process consists of reacting sulphuric acid with dried fluorspar (CaF_2) in one of four indirectly fired kilns. A mixture of sulphuric acid and oleum is used to provide the required drying. The reaction results in the release of hydrogen fluoride gas and the production of a fluorogypsum solid byproduct. The reaction is:

$$CaF_2 + H_2SO_4 \longrightarrow 2HF + CaSO_4$$

The calcium sulphate ($CaSO_4$) produced is actually about 85 percent $CaSO_4$, about 10 percent $CaSO_4.1/2\ H_2O$ and about 5 percent $CaSO_4.2H_2O$.

Table 2.1
Uses of Hydrofluoric Acid

Market	Use	Products
Anhydrous Hydrofluoric Acid		
Aluminum Manufacture	Production of aluminum fluoride and cryolite	Source of all aluminum metal
Atomic Energy	Production of uranium hexafluoride	Nuclear industry
Chemical Manufacturing	Electrolytic production of elemental fluorine Production of inorganic. Fluoride salts	Transformer fluids. Water repellant products Stannous Fluoride (toothpaste). Fluoridates water
Organic Chemical Manufacturing	Production of fluorocarbon. Production of household products	Refrigerants. Scotchguard, stain resistant materials
Petroleum Refining	Alkylation	Catalyst
70% Aqueous Hydrofluoric Acid		
Alloy Steel Manufacturers	Pickling	Removes scale and rust
Chemical Manufacturers	Production of fluorine compounds	Source of fluoride ion
Foundries	Cleaning iron and steel castings	Dissolves sand to produce pure metal products
Glassmakers	Polishing, etching and frosting glass	Television tube, frosted, fine crystal ware
Metal Finishers	Electroplating metals	Proves a viscous layer that permits dissolving metal surface without pitting. Used to machine exotic metal parts.
Mines	Froth flotation of ores	Depressant. Higher yield or ore
Sand Products	Washing sand free of iron	Dissolves silica to loosen surface iron stains - produces a pure silica
AlF_3		
Aluminum	Production of aluminum	Lower melting point and increased conductivity of electrolyte
Ceramics Manufacturing	Flux	Ceramic glasses and enamels

The hydrogen fluoride is drawn off the feed end of the furnace as shown in the Figure A.1. The hydrogen fluoride is than recovered by condensation and can be sold as commercial grade or purified by distillation. Figure A.2 presents a flow diagram of the high purity distillation system.

Hydrofluoric acid solution is prepared by simply adsorbing the gaseous hydrogen fluoride in water. Aluminum fluoride is produced by dehydrating aluminum hydrate and reacting the resulting solid with gaseous hydrogen fluoride. Figure A.3 shows a flow diagram for the aluminum fluoride.

The solid byproduct, fluorogypsum, is immediately slurried with recycled pond water and transported in a 3-5% slurry to the active gypsum stacks. The pH of the water in the recycle system is in the range of pH 2 as a result of the residual acidity of the solids. The acidity results from adsorbed sulphur trioxide as well as minor amounts of absorbed hydrogen fluoride.

3.0 WASTEWATER MANAGEMENT

Allied pumps water from the nearby Mississippi River and treats this water in a clarifier before distributing it for process use in its own facility and the adjacent plants. Figure A.4 shows the layout of the approximately 32-hectare active area. Areas 1 and 2 are fluorogypsum stack areas that are presently inactive. Areas 3 and 4 are currently being used for solids disposal. At the time of the site visit, solids were being deposited in Area 4. The liquid is decanted from the surface using a floating weir arrangement. The wastewater is retained in the auxiliary clear well and flows by gravity to the clear well from which it is pumped for reuse in the plant scrubbers, is reused for transporting slurry or is treated and discharged. Figure A.5 presents a schematic of the water flows and uses at the Geismar facility.

3.1 Wastewater Treatment

Wastewater from the Geismar hydrogen fluoride plant, as shown in Figure A.5, results from several process units including air pollution scrubbers, cooling tower blowdown, plant washings for housekeeping, pump seal fluid, and steam condensate. Rainfall contributes significantly to the wastewater system.

The wastewater is reused as scrubber water and to slurry the fluorogypsum co-product for transport to the storage piles for long-term reclamation as a construction aggregate. After settling the fluorogypsum, water is decanted and stored in impoundments for return to the plant for reuse. Excess wastewater is treated in a neutralization unit prior to discharge to surface waters.

The acidic wastewater is fed to an elevated agitated neutralizer where it is mixed with a slaked lime and a flocculation enhancing polymer. Neutralized wastewater flows by gravity to a large clarifier, and sludge is withdrawn to the fluorogypsum storage facility. The clarified water overflows to a pump tank for discharge. A pH-activated diversion system has been installed on the pump tank to prevent out-of-limits effluent from being discharged. A monitoring station downstream of the diversion system continuously records flow and pH observations and collects flow proportional samples for laboratory analysis.

Lime usage in 1990 was reported to be 5,450 tonnes.

Permit limits for the facility are presented in Table A.1.

The removal efficiency of the treatment process for several key parameters are presented in Table A.2.

Table A.3 presents a copy of a summary of the water discharge parameters for 1990 and the first half of 1991.

4.0 SOLID WASTE DISPOSAL

The slurried residue from the hydrogen fluoride kilns is discharged on the periphery of the active stack. The water flows to the central pond and deposits solids in a delta formation as it flows. The discharge line is periodically moved around the periphery of the stack and thus, the solids buildup around the edge of the active stack.

As the solids dry, they form a solid material which is described by Allied as having strength properties similar to green concrete.

At the present time, Allied has a contract with an aggregate company who is, in effect, mining aggregate from the areas identified as Stack 2. This company is using a pavement profile machine to remove the solidified fluorogypsum in approximately 15 cm layers.

In 1990, this company removed approximately 260,000 tonnes of fluorogypsum and sold it as aggregate in the local market. This operation is possible since there is no other source of aggregate available locally. In the past, dredged shells were used in this geographic area, but environmental concerns have closed down the dredging operations. The other source of aggregate is limestone, which is barged from up-river sources. These factors make aggregate expensive in this location and have provided an opportunity for this use of the fluorogypsum aggregate.

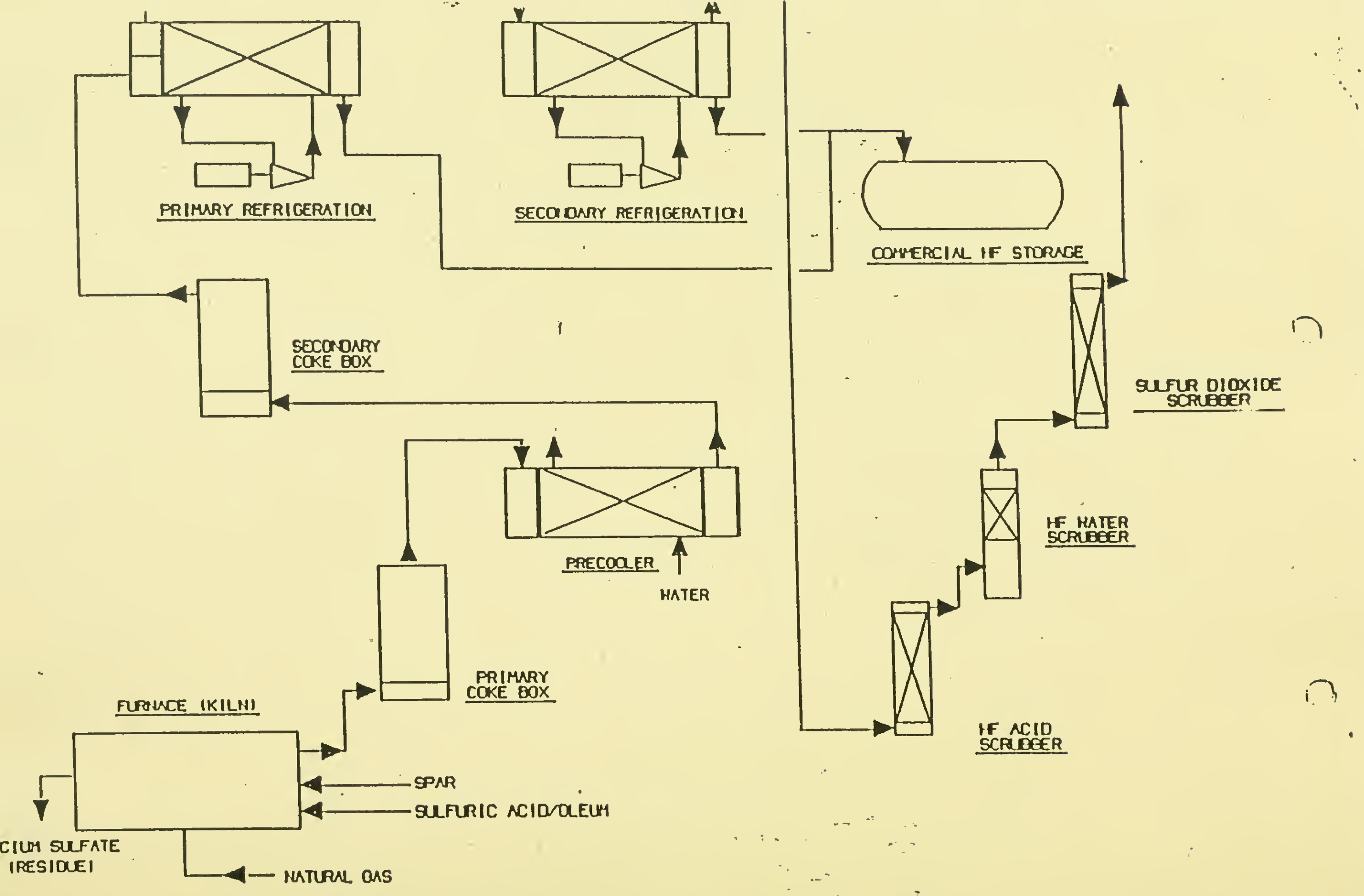
Allied staff indicated that European hydro fluoride facilities utilize the solid residue dry as a filler material in concrete structural panels that are well accepted in the European marketplace. The residual sulphur trioxide and hydrogen fluoride do cause handling problems and make storage difficult. The concrete structural panels are apparently widely used in Europe, while such construction approaches are not well accepted in North America.

5.0 AUDIT TEAM

Frank A. Ryan, Ontario Ministry of the Environment
Art Stelzig, Environment Canada
Deborah Ross, CH2M HILL
Leo C. Ehrenreich, SAIC

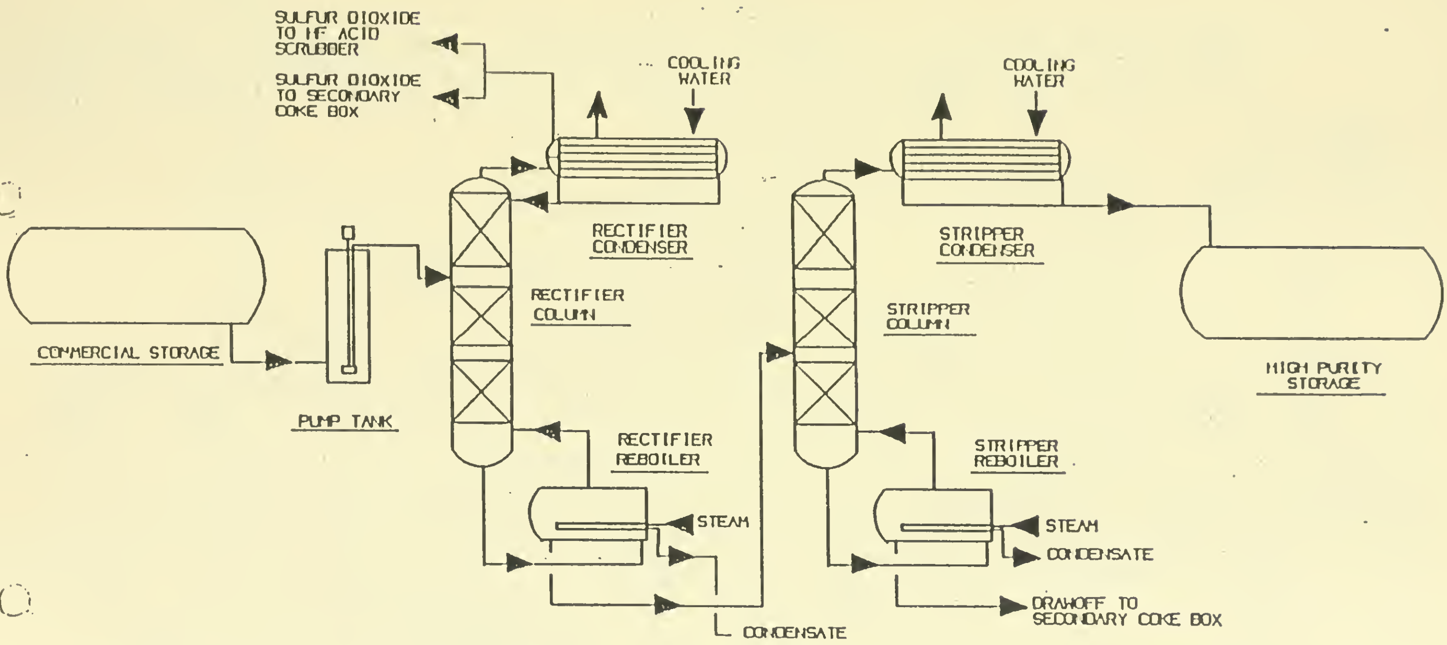
APPENDIX

Tables and Figures



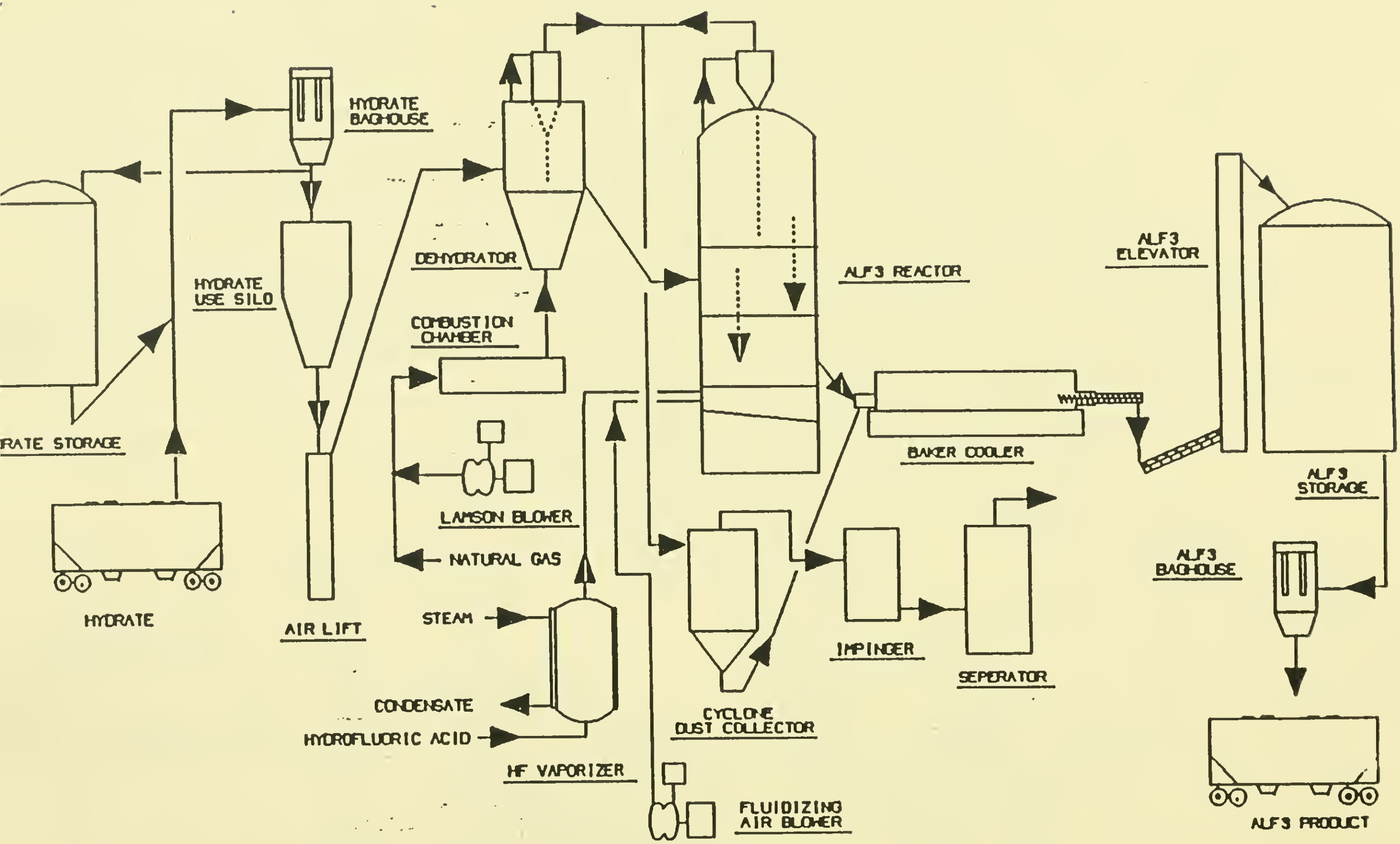
HYDROFLUORIC ACID PROCESS

Figure A.1



HIGH PURITY DISTILLATION SYSTEM

Figure A.2



ALUMINUM FLUORIDE PROCESS

Figure A.3

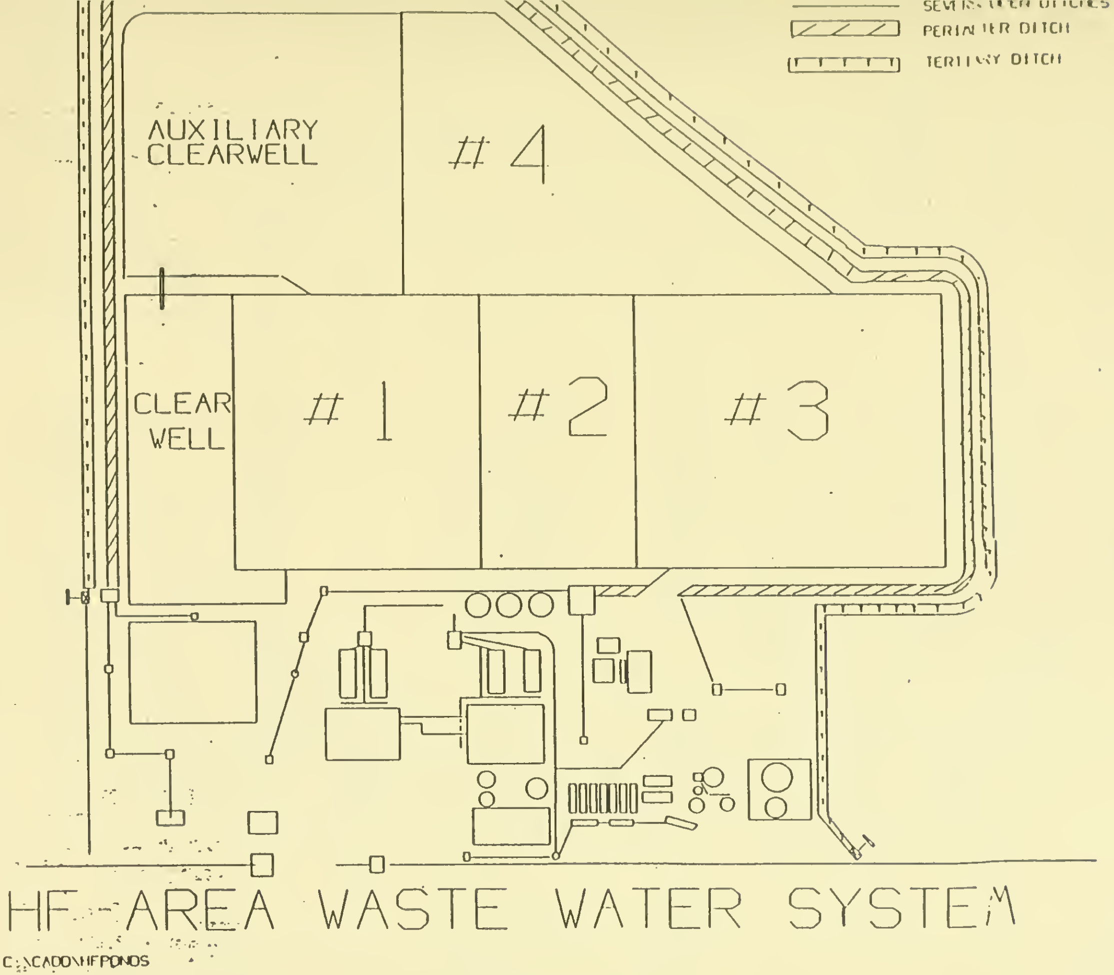
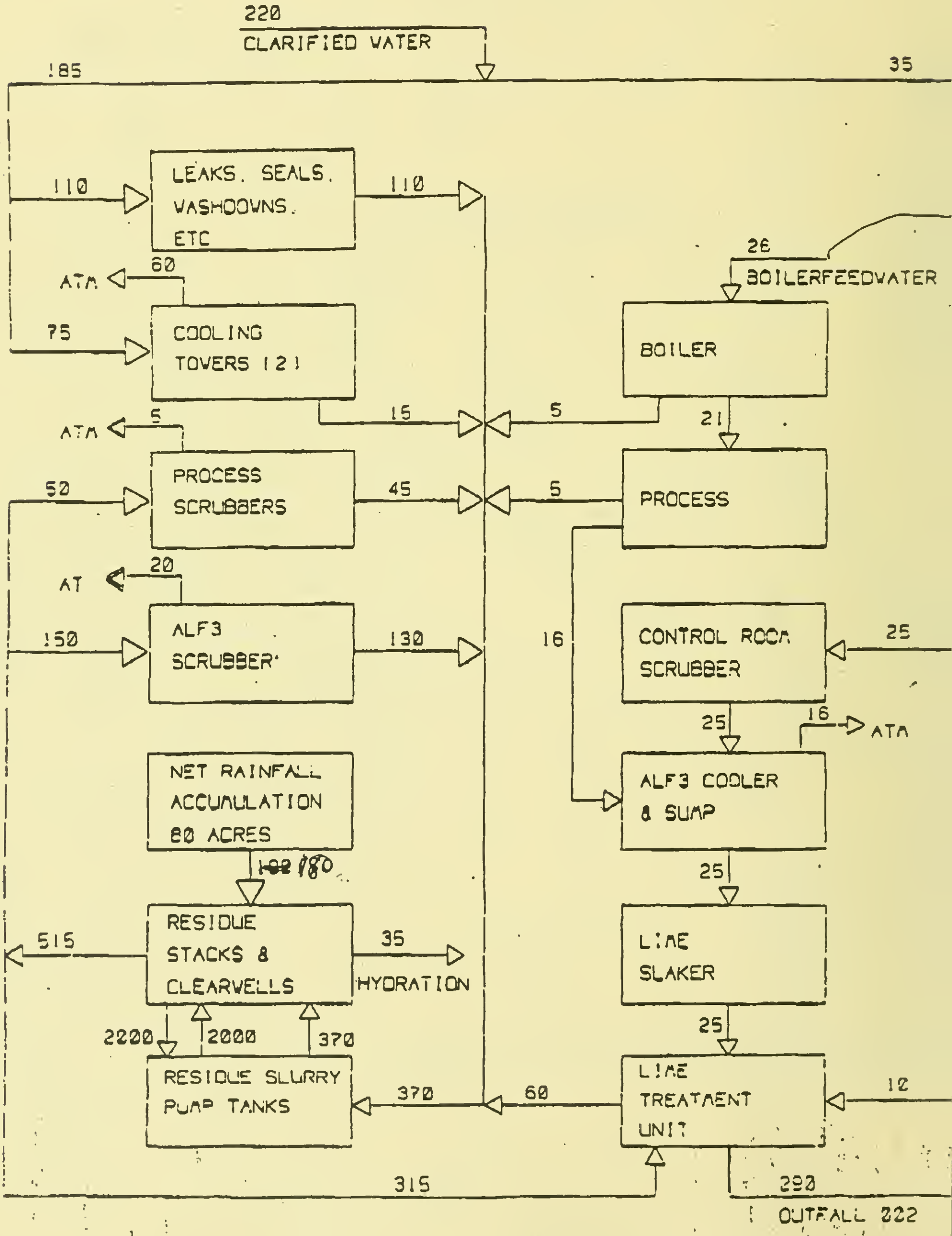

PERIMETER DITCH
TERTIARY DITCH
AUXILIARY CLEARWELL
# 4
CLEAR WELL
# 1
# 2
# 3
HF AREA WASTE WATER SYSTEM
C:\CADD\HFPONDS

Figure A.4

ALLIED-SIGNAL, GEISMAR, LA
SCHEMATIC OF WATER FLOWS



ALL FLOWS IN GALLONS PER MINUTE (GPM)

Table A.1
Geismar Plant Permit Limits
Permit Number LA 0006181

pH	Continuous recording monitor Report minimum and maximum
TSS	Daily average for month: 3,362 lbs/day (1,528 kg/d) Maximum for one day: 6,956 lbs/day (3,162 kg/d) 24-hour composite 3 times per week
Total Fluoride	Daily average for month: 1,079 lbs/day (490 kg/d) Maximum for one day: 2,284 lbs/day (1,038 kg/d) 24-hour composite 3 times per week
Total Chromium	Daily average for month: 5.0 lbs/day (2.27 kg/d) Maximum for one day: 16.2 lbs/day (7.4 kg/d) 24-hour composite 3 times per week
Total Nickel	Daily average for month: 4.1 lbs/day (1.86 kg/d) Maximum for one day: 18.5 lbs/day (8.41 kg/d) 24-hour composite 3 times per week
Total Zinc	Daily average for month: 12.8 lbs/day (5.82 kg/d) Maximum for one day: 41.8 lbs/day (19.0 kg/d) 24-hour composite 3 times per week
Flow	Continuous recording monitor Report average and 24-hour maximum

Table A.2
Performance of Wastewater Treatment System at Allied Signal, Geismar Plant

Parameter	Influent Concentration (mg/L)	Effluent Concentration (mg/L)	Removal (%)
Chromium	1.5	0.04	97
Nickel	4.4	0.45	90
Zinc	26.5	0.25	99
Fluoride	2,400	28.9	99

Notes:

1. Average results of monitoring in 1990 and January to June, 1991.

WATER DISCHARGES 1990

MONTH	FLOW AVERAGE mgd	FLUORIDE AVERAGE klbs/day	Cr AVERAGE	Zn AVERAGE	Ni AVERAGE	TSS AVERAGE	FLOW TOTAL mg ←	FLUORIDE TOTAL lb/mo	Cr TOTAL	Zn TOTAL	Ni TOTAL	TSS TOTAL
JAN	0.552	237	0.3	2.0	2.8	415	17.112	7347	9.3	62.0	86.8	12865
FEB	0.527	136	0.3	1.3	2.9	89	14.756	3808	8.4	36.4	81.2	2492
MAR	0.582	144	0.2	1.6	3.6	78	18.042	4464	6.2	49.6	111.6	2418
APR	0.608	125	0.4	0.8	2.4	27	18.240	3750	12.0	24.0	72.0	810
MAY	0.454	99	0.2	1.5	2.3	20	14.074	3069	6.2	40.3	71.3	632
JUN	0.262	116	0.8	4.1	6.6	60	7.860	3480	24.0	123.0	198.0	1800
JUL	0.359	78	0.1	1.3	1.9	58	11.129	2418	3.1	40.3	58.9	1798
AUG	0.117	87	0.2	0.7	1.1	36	3.627	2697	6.2	21.7	34.1	1116
SEP	0.164	71	0.1	1.3	1.8	28	4.920	2130	3.0	39.0	54.0	840
OCT	0.267	120	0.2	2.0	1.7	28	8.277	3720	6.2	62.0	32.7	868
NOV	0.197	83	0.2	2.0	1.0	33	5.910	2490	6.0	60.0	30.0	990
DEC	0.411	185	0.2	2.4	2.5	36	12.741	5735	6.2	74.4	77.5	1116
						TOTALS	mg/yr ↓ 136.688	#/yr 45108 lbs	97	632.7	928.1	27745.4
						DAILY AVG	0.374 mgd	124 ← #/day →	0.27	1.73	2.54	76
						CONC	PPM	39.6 O.K.	0.08	0.56	0.81	24.34

Table A.3
Wastewater Discharge Data for Allied Geismar

WATER DISCHARGES 1991

MONTH	FLOW AVERAGE MGD	FLUORIDE AVERAGE lbs/day	Cr AVERAGE lbs/day	Zn AVERAGE lbs/day	Ni AVERAGE lbs/day	TSS AVERAGE lbs/day	FLOW TOTAL MGD/yr	FLUORIDE TOTAL lbs/yr	Cr TOTAL lbs/yr	Zn TOTAL lbs/yr	Ni TOTAL lbs/yr	TSS TOTAL lbs/yr
JAN	0.451	155	0.2	1.4	2.5	28	13.981	4805	6.2	43.4	77.5	868
FEB	0.492	180	0.2	0.8	2.2	27	13.776	5040	5.6	22.4	61.6	756
MAR	0.398	124	0.1	0.9	1.0	15	12.338	3844	3.1	27.9	31.0	465
APR	0.399	88	0.1	0.9	1.4	20	11.970	2640	3.0	27.0	42.0	600
MAY	0.674	101	0.3	2.4	3.0	24	20.894	3131	9.3	74.4	93.0	744
JUN	0.555	67	0.2	0.4	1.1	24	16.650	2010	6.0	12.0	33.0	720
JUL												
AUG												
SEP												
OCT												
NOV												
DEC												
TOTALS(/yr)							89.609	23470	33	207.1	338.1	4153
DAILY AVG(/dy)							0.495	119	0.18	1.14	1.87	23
CONC							PPM	28.7	0.04	0.28	0.45	5.56

Table A.3
Wastewater Discharge Data for Allied Geismar

Section 4
TECHNOLOGY REPORTS

TECHNOLOGY REPORT
POND LINERS

1.0 DESCRIPTION

The purpose of pond liners is to virtually eliminate the leaching of the contents of waste, wastewater or storm water retention ponds to the underlying soil and water table. There are two major groups of liner technologies. These are:

- Flexible membrane linings (FML), including polyvinyl chloride (PVC), chlorinated polyethylene (CPE), high density polyethylene (HDPE), chlorosulphonated polyethylene (CSPE, commonly known by its trade name, Hypalon) and others.
- Earth materials including clay and soil/bentonite mixtures.

2.0 APPLICATION

Lined ponds are commonly used for liquid industrial and municipal wastewater or sludge or impoundment. In the Ontario Inorganic Chemical Sector, several plants currently use unlined ponds which contain wastewater. Lining of ponds is being considered for these plants. In addition, at one plant, where an intake water pond is sited in potentially contaminated soils, lining is being considered to prevent contamination of intake water.

3.0 DESIGN INFORMATION

The basis of design for pond liners is the desired permeability of the liner material. Lower values of permeability provide the greatest protection to the underlying water table. Permeabilities are essentially a measure of the apparent velocity of contaminants through the liner material. Typical values of permeability for liquid waste storage ponds are 10^{-7} cm/s, although values as low as 10^{-10} cm/s have been claimed by some pond liner manufacturers under ideal conditions.

Both FML and earth material pond liner technologies involve the preparation of appropriate foundations and berms. Pond bottoms should be carefully sloped, preferably at or above 3 percent grade. The subgrade must be free of any objects which may result in stress to the liner once it is placed and the pond is filled. Soil covers required over some types of liners should be placed as soon as possible after placement of the liner in order to avoid problems associated with moisture control.

A flexible membrane liner should have a continuous layer of sand placed on the subgrade to allow for venting of air pushed upward by a rising water table. The steepness and length of berm sideslopes are generally dictated by the following factors:

- Storage volume requirements and space limitations
- Slope stability/foundation stability
- Ease of construction
- Resulting stresses on the flexible membrane liner or stability of the liner soil cover
- Erosion protection
- Operations and maintenance concerns
- Regulatory requirements.

4.0 PERFORMANCE

Performance of liners is measured by the degree to which contaminants are prevented from leaching out of the pond. Design permeability and sampling programs after commissioning are two means to assess performance.

5.0 OPERATING REQUIREMENTS

By their nature, lined ponds have relatively few operating and maintenance requirements. The major requirement will be monitoring of ground water to ensure that significant leaching is not occurring.

6.0 CAPITAL COSTS

The following discussion presents approximate capital costs for liner materials, as well as some estimates of installation fees. Comprehensive capital costs for implementation of pond liners cannot be developed until site-specific factors have been defined.

The relative merits of various flexible membrane liner technologies are compared in Table 1.

Table 1
Flexible Membrane Liner Material Characteristics

Membrane Material	Tear Strength	Elongation	Chemical Resistance	Relative Installation Ease	Relative Cost	Requires Soil Cover
Polyvinyl Chloride (PVC)	2	4	1	5	3	yes
PVC - Oil-Resistant	2	4	2	5	4	yes
Chlorinated Polyethylene (CPE)	4	2	2	3	3	no
CPE- Oil-Resistant	4	2	3	3	3	no
Elasticized Polyolefin	4	5	4	2	3	no
Neoprene	2	3	5	3	5+	no
High-Density Polyethylene (HDPE) Unreinforced	5	5	5	1	3	no
Epichlorohydrin Rubbers	2	3	4	3	5+	no
Chlorosulphonated Polyethylene (CSPE), (Hypalon), Reinforced	4	1	1	4	4	no
Butyl Rubber	2	3	4	3	5+	no
Ethylene Propylene Rubber (EPDM)	2	3	4	3	5+	no
Key: 1	Weak	Little	None	Difficult	Low	\$2.50-\$3.75/m^2 (1)
2						
3	Adequate	Moderate	Moderate	Typical	Medium	\$6.25-\$8.75/m^2 (1)
4						
5	Strong	High	High	Easy	High	\$10.00-\$15.00/m^2 (1)

Note:

1. Based on ENR CCI (Toronto) 6343.

The following assumptions apply to these costs:

- Costs are in 1991 Canadian dollars, based on ENR CCI (Toronto) 6343.
- Ranges in costs represent differences in material thicknesses, geographic location, etc.
- Installation not included. Labour costs for installation may range from \$1.25 to \$3.25/m^2, depending on liner system.
- Costs are applicable to surface impoundment areas of between 9,000 to 25,000 m^2.

- Average access for construction has been assumed.

- Pond design is based upon sideslopes of 3:1, and depth of 3 to 6 m.

Site specific factors and economics will determine which flexible membrane liner technology is best suited to any particular application.

Liners constructed of earth materials such as clay or soil/bentonite are strongly dependent on construction techniques for their structural integrity. Proper techniques for the placement and compaction of these materials are required to achieve design specifications for permeability, usually set at 10^{-7} cm/s. Table 2 presents information on costs for clay and soil/bentonite liners.

Table 2
Costs of Earth Material Liners

Type of Liner	Cost (1991 $CDN per m^3)[1]
Clay	10.00 to 50.00
Soil/Bentonite	60.00 to 120.00

Note:

1. Based on ENR CCI (Toronto) at 6343.

Assumptions used in the development of costs for clay liners include:

- Haul distances for earth materials of less than 20 km.
- Installation and labour included.

Assumptions used in the development of costs for soil/bentonite liners include:

- Delivery of bentonite to job site included, but not mixing with soil nor installation and associated labour.

- Soil used is native material and suitable for blending with bentonite.

- Bentonite used is highly contaminant resistant (up to 100,000 mg/L TDS).

- Design permeability: 10^{-7} cm/s.

- Bentonite application rate: 200 to 300 kg/m^3 of liner

The costs presented above are approximate, and can vary widely depending on specific factors associated with each individual application. Factors that will influence costs include:

- Site hydrogeological characteristics soil conditions and available land area (for berm construction).
- Interim storage requirements during pond construction.
- Site decommissioning, including clean-up requirements.
- Location of site and haul distance from construction materials.
- Climate.

7.0 OPERATING COSTS

Operating costs for lined ponds will consist of ground water and any other monitoring which may be required, and will be dependent on the extent of these programs. Should the monitoring program reveal any breaches in the integrity of the liner, decommissioning and repair may be required. These costs will be entirely dependent on the severity of damage to the liner, as well as the type of liner involved.

8.0 REFERENCES

1. CH2M HILL ENGINEERING LTD., 1989. *Design Manual for Liquid, Solid and Hazardous Containment Systems.* In-house document.
2. ENR CCI. Engineering New Record Construction Cost Index, March 1991.

TECHNOLOGY REPORT
PUMPING STATIONS, FORCEMAINS AND SEWERS

1.0 INTRODUCTION

Implementation of BAT options applicable to Ontario facilities in the Inorganic Chemical Sector requires the consideration of site specific factors that would affect the capital and operating costs. One of the primary factors is the existing wastewater collection and pumping system, and the changes that would be necessary to transfer water to and from the BAT technology. This report presents a basis for costing additional sewers, forcemains and pumping stations necessary for implementation of BAT options.

2.0 DESCRIPTION

The following assumptions have been made to provide cost estimates for pumping stations, sewers and forcemains:

- All construction costs assume average water table level, average soil conditions, no existing obstructing facilities, no deep excavations and an available power supply.
- For design flow rates of 10 to 100 L/s, pumping stations consist of precast concrete sumps with two submersible pumps (Figure A1).
- For design flows over 100 L/s, pumping stations consist of a cast-in-place rectangular, concrete wet well, with pumps mounted on a covering slab, and housed in a light industrial type building. Pumps are self-priming trash type (Figure A2).
- The sewer diameter has been specified based on a one percent slope and being 50 percent full at design flow rate.
- The cover over the incoming sewer was assumed to be 2.5 m, while the cover over forcemain of was assumed to be 1.5 m.
- Forcemain diameters have been specified to assure a water velocity of 1 to 1.5 m/s.
- Standby power has not been included.

3.0 COSTS

Cost for pumping stations, forcemains and sewers described above are based on the following:

- Unit cost for:

-	Excavations,	$\$10/m^3$
-	Backfill,	$\$5/m^3$
-	Concrete structures including bars, formwork, etc.	$\$600/m^3$
-	Building, including services,	$\$2,700/m^3$

- Equipment prices are from the vendor and include a 30 percent allowance for installation.

- Valving and piping costs are estimated separately.

- All costs include installation, a 30 percent estimating contingency, a 15 percent allowance for engineering and seven percent G.S.T.

- ENR CCI at 6343.

Table 1 presents the estimated costs of pumping stations, forcemains and sewers for a range of design flow rates. Figure 1 presents the corresponding plot of capital cost versus design flow rate for pumping stations.

4.0 REFERENCES

1. ENR CCI Engineering News Record Construction Cost Index for Toronto, March, 1991.

Table 1

Estimated Cost of Pumping Stations, Forcemains and Sewers for a Range of Flow Rates

Flow (L/s)	Pumping Station Capital (Cost $)[3]	Operating and Maintenance Approximate Cost ($/year[1])[3]	Forcemain Diameter (mm)	Forcemain Unit Cost ($/m)	Sewer Diameter (mm)	Sewer Unit Cost ($/m)	Remarks
10	25,000	2,500	100	161	200	180	Pumping station is precasted circular concrete sump, two alternating submersible pumps, in on/off operation. No building; controls in existing building or in weatherproof panels.
20	27,000	2,000	150	185	300	240	
40	33,000	4,000	200	220	400	310	
80	77,000	6,000	250	285	500	350	
150	290,000	12,000	350	405	700	490	Pumping station as a light building constructed on cast in place concrete rectangular wet well. Three set primary pumps, two in on/off operation.
300	400,000	28,000	500	630	800	760	
400	470,000	35,000	600	805	1,000	340	Pumping station as above but with four pumps, three in on/off operation.
500	560,000	40,000	600	805	1,100	1,000	

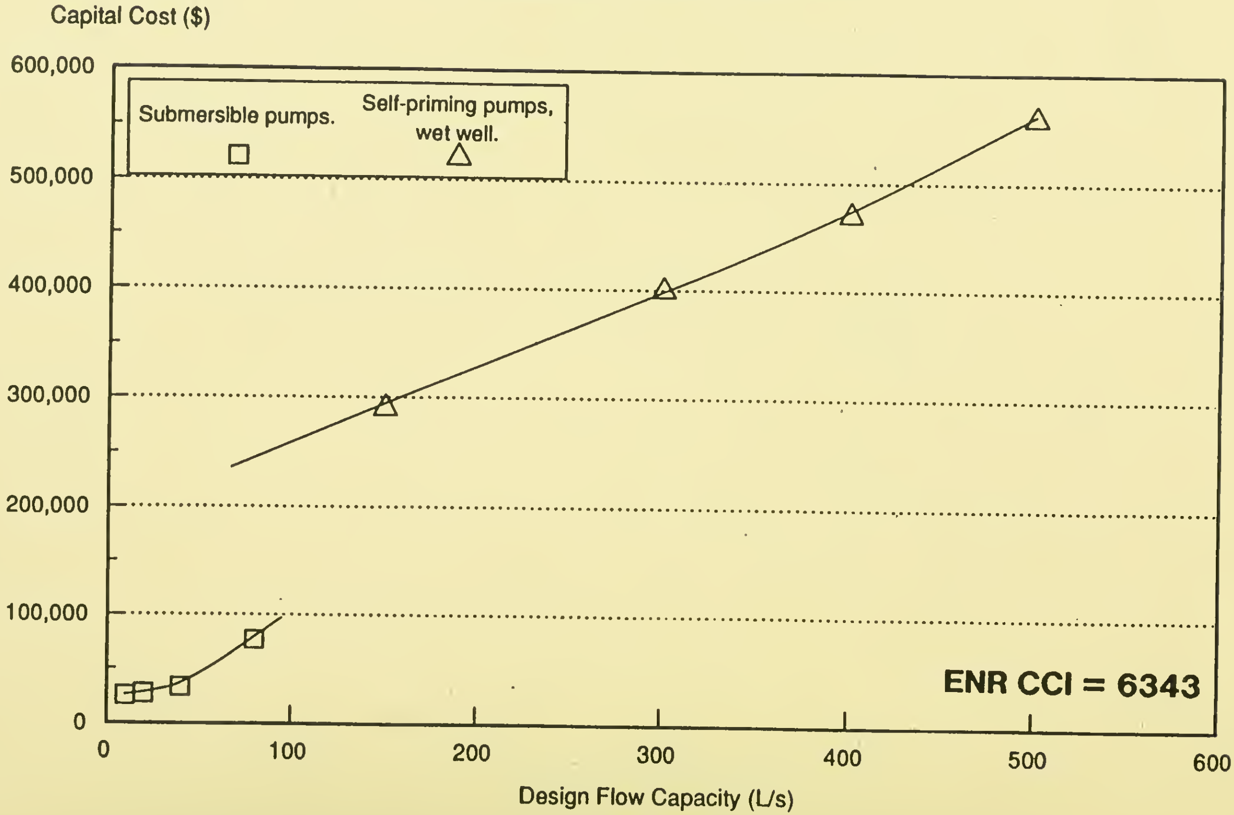
Notes:

1. Based on ENR CCI (Toronto) at 6343.
2. Capital cost includes 35% allowance for equipment installation, 30% estimating contingency, 15% engineering and 7% G.S.T.
3. Operating costs include maintenance labour and materials, and electricity.

APPENDIX

Figures

Figure 1
Estimated Cost of Pumping Stations for a Range of Flow Rates



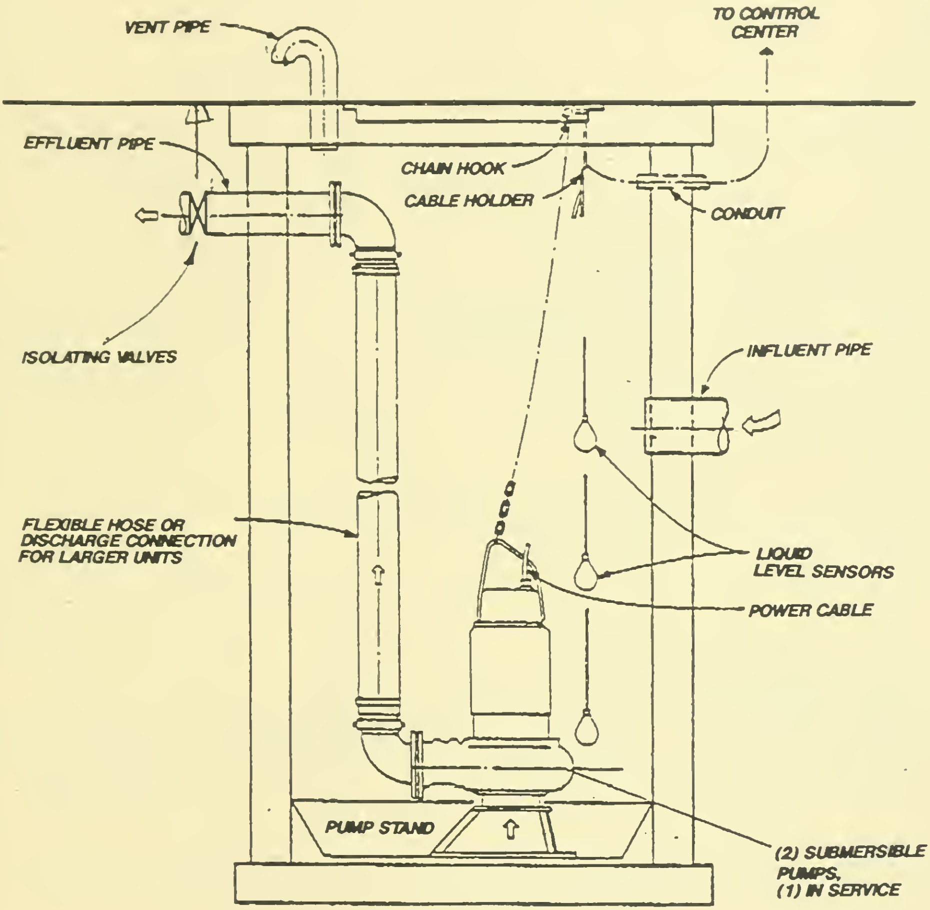


Figure A1
TYPICAL PUMPING STATION ARRANGEMENT
SUBMERSIBLE PUMPS

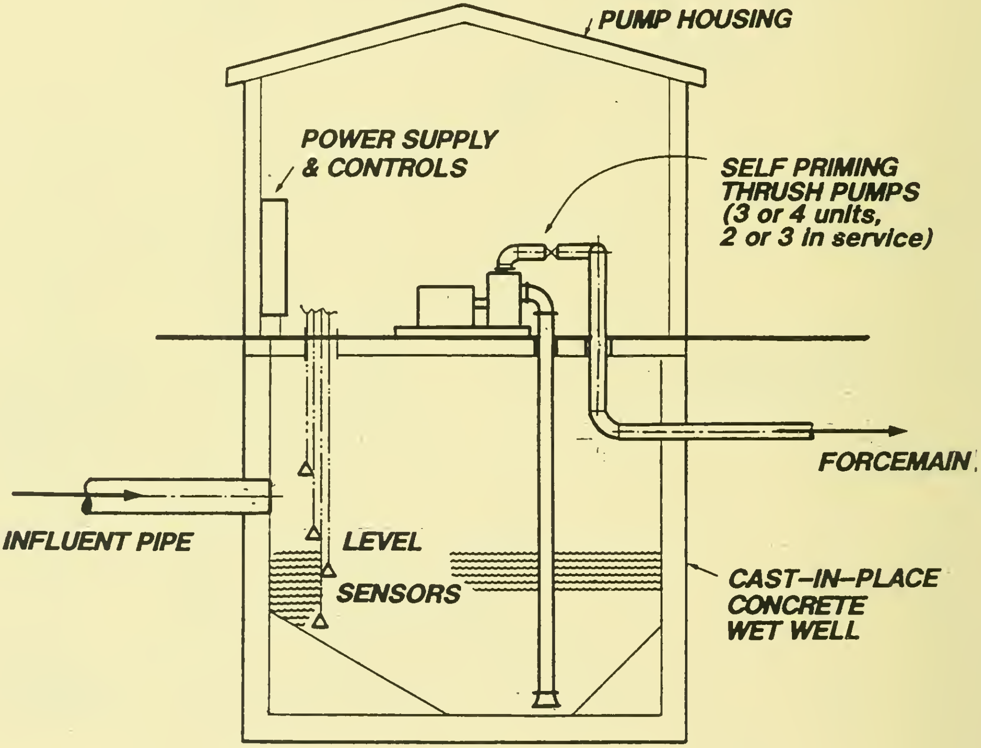

PUMP HOUSING
POWER SUPPLY & CONTROLS
SELF PRIMING THRUSH PUMPS (3 or 4 units, 2 or 3 in service)
FORCEMAIN
INFLUENT PIPE
LEVEL SENSORS
CAST-IN-PLACE CONCRETE WET WELL

Figure A2
TYPICAL PUMPING STATION
–Wet Well, Self Priming Pumps

TECHNOLOGY REPORT
SETTLING/SEDIMENTATION FOR TSS REMOVAL

1.0 DESCRIPTION

Settling/sedimentation is a process used to remove suspended solids (TSS) from aqueous waste streams by gravity separation. The wastewater is fed to a vessel, basin or pond, etc., which provides a quiescent zone where the phases separate.

Primary clarification consists of a settling tank as shown in Figure A1, with a detention time of 1.5 to 3 hours which provides a quiescent environment. Both rectangular and circular clarifiers are used. Alternatively settling may take place in a concrete tank or lagoon/pond. Settling tank or basin depths typically range from 3 to 4.5 m. Settled solids may be mechanically collected on the bottom of the basin/tank and pumped as sludge underflow, or pumped out periodically with vacuum pump or trucks. Sludge underflow may be disposed off site directly or dried in sludge drying beds, and subsequently dried sludge is disposed. More elaborate systems may use sludge thickeners and mechanical dryers.

Settling of solids may also be carried out in lagoons. Details on this type of system are provided in the Sister Plant Report for Cabot Canada (Ref. 1).

2.0 GENERAL APPLICABILITY

Removal of suspended solids by settling/sedimentation has been used in both municipal and industrial water and wastewater treatment applications. The process is especially well suited to handle influent streams containing high levels (> 50 mg/L) of easily settleable solids. In cases where finer materials are present, chemical coagulants such as alum, iron salts and/or polymers are used to assist in the settling process.

Removal of suspended solids by settling/sedimentation is used in a variety of industries including food processing, pulp and paper, chemical processing, oil refining, municipal water/wastewater treatment for a number of applications.

3.0 ONTARIO APPLICATION

For this study, settling/sedimentation with or without chemical addition is applicable the removal of suspended solids from effluents generated in general industrial processes, such as boiler and cooling tower blowdown, stormwater runoff, as well as other process streams that have a high TSS level or have been chemically treated to precipitate specific target contaminants.

4.0 DESIGN

Table 1 presents typical design parameters for primary clarifiers or settling basins.

Table 1
Typical Design Parameters for Clarifiers or Settling Basins

Parameter	Ranger
Overflow rate	21 - 49 $m^3/m^2/d$
Detention time	1.5 to 3 hr
Weir loading	125 - 375 $m^3/m/d$
Rectangular basin length to width ratio	Minimum of 4

5.0 PERFORMANCE

Table 2 provides estimated performance ranges for removal of suspended solids in settling systems with and without chemical addition.

Table 2
Typical Performance of Settling Systems With and Without Chemical Addition[1,2]

Technology	Effluent TSS Concentration (mg/L)		Removal Efficiencies (%)	
	Range	Median	Range	Median
Settling	<1-2,300	20	20 - >99	91

Notes:

1. Performances will vary widely depending on the settleability of the solids and chemicals used.
2. Ref. 4.

6.0 OPERATING REQUIREMENTS

The main operating requirements of a sedimentation system are sludge removal and disposal. In a clarifier system, sludge will be removed as an underflow, that is blown down automatically or manually to a holding tank, thickener or drying bed. In a settling basin, sludge will be removed periodically, by vacuum truck or pump depending on the rate of buildup and storage capacity, and may be disposed directly or placed in a sludge drying bed. Dried sludge solids may be hauled to a secure or municipal landfill, depending on their quality. Recovery of sludges may also be practised. At abrasives plants in the Ontario Inorganic Chemical Sector, for example, solids are valuable raw materials and are recovered for use in the process.

Labour requirements will vary significantly, depending on the size, complexity and level of automation of the system. For example, a settling sump will require virtually no labour except periodic clean-outs, which may be carried out by contracted hauler. A complex system of chemical addition, settling tanks with thickeners, and drying beds may require a full time operator. Additional labour will be needed where chemicals are used, to inspect dosage controls, order and possibly mix chemicals, and periodically check dosage rates.

Power requirements will vary depending on mechanical equipment used and pumping.

7.0 CAPITAL COSTS

Table 3 presents capital costs and cost exponents for different components of settling systems. Cost estimates can be extrapolated for similar sizes (± 100%) using the following equation:

$$Cost_2 = \left(\frac{Surface\ Area_2}{Surface\ Area_1}\right)^{Exponent} x\ Cost_1$$

Table 3
Capital Costs and Exponents of Sedimentation Systems[1,2]

Component	Cost	Exponent
Steel circular clarifier, above ground, 6 m diameter, scraper & drive.	$330,000	0.5
Concrete tank, no mechanical equipment or sludge removal mechanism (25 m^2 surface area).	$35,000	0.6
In-ground concrete settling tank with mechanical scraper (120 m^2 surface area).	$810,000	0.5
Chemical dosage system including 2 pumps, dosage controller, 2,000 L chemical storage tank.	$27,000	0.3

Notes:

1. All costs include 30 percent installation 35 percent estimating contingency, 15 percent engineering and 7 percent GST (on total) (ENR CCI 6343).
2. From CH2M HILL in-house information.

Sludge drying beds are simply lined lagoons, with a shallow liquid depth (less than 1 m) that allow evaporative drying of sludge solids, which can subsequently be disposed.

Pond construction costs can be developed from the Sister Plant Report for Cabot (Ref. 1) and pond linings are described in the General Technology Report (Ref. 2).

8.0 OPERATING COSTS

Operating costs will vary widely, depending on the size and complexity of the operation. Labour and power requirements can only be determined on a case by case basis. Jar tests are necessary to confirm chemicals and dosages that will optimize removal. Table 3 presents typical 1991 sludge disposal costs.

Table 4
Typical Sludge Disposal Costs

Method	Cost
Vacuum truck for liquid sludge haul	$350/m^3
Municipal landfill	$100 - $200/t
Secure landfill	$350/t

9.0 REFERENCES

1. Sister Plant Technology Report - Coagulation Settling/Filtration Ponds at Cabot Canada Ltd.

2. General Technology Report - Pond Linings.

3. Drew Chemical Corporation - Principals of Industrial Water Treatment. 1983.

4. Treatability Manual Volume III - Technologies for Control/Removal of Pollutants, U.S. EPA, EPA-600/2-82-001c. September 1981.

APPENDIX

Figure

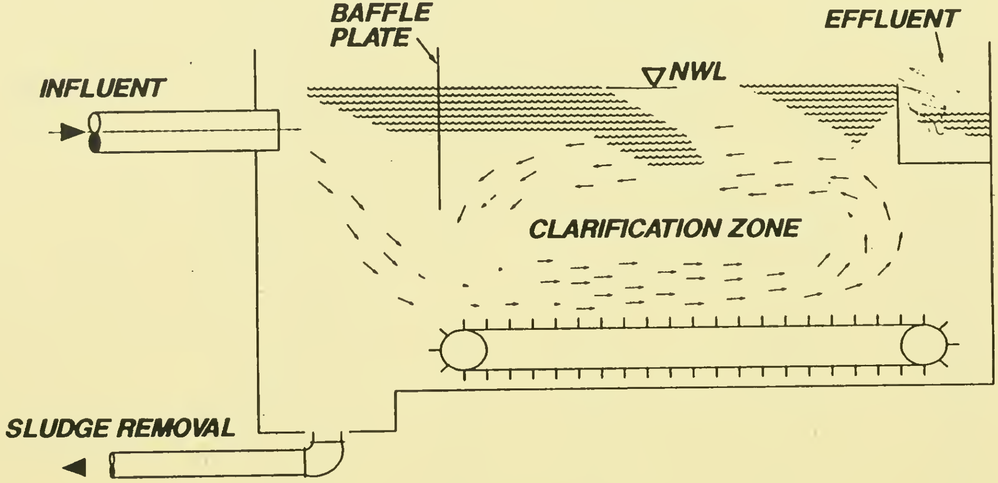


Figure 1

SCHEMATIC OF

A CONVENTIONAL SETTLING BASIN

TECHNOLOGY REPORT
WATER CONDITIONING CHEMICALS FOR BOILER AND COOLING TOWER MAKE-UP

1.0 INTRODUCTION

Water conditioning chemicals are added to boiler and cooling tower make-up water by many facilities in the Ontario Inorganic Chemical Sector. These chemicals are added to control:

- corrosion
- scaling
- foaming
- microbiological growth

During cooling tower and boiler operations, contaminants introduced either in the raw water or by addition of water conditioning chemicals, concentrate and are present at elevated concentrations in the blowdown, resulting in potentially toxic effluents.

Rather than implementing end-of-pipe treatment, the preferred method to minimize or avoid toxic effluents is to use alternative water conditioning chemicals.

2.0 DESCRIPTION

Table 1 presents a list of all the facilities who used water treatment chemicals for boiler and cooling tower make-up water during the MISA Monitoring Regulation period, and who discharge blowdown from these operations directly. In this Table, the flow, the additives, and contaminants of possible concern are identified. Contaminants of possible concern were selected considering the components of water treatment chemicals, and the most frequently identified "Priority 1" pollutants as defined by the Ministry of the Environment during the MISA Monitoring Regulation period.

The selected contaminants include:

- zinc/chromate
- phosphate/phosphate derivatives
- chlorine/chloride
- bromine/bromide

Zinc/chromate-based chemicals used in the past for corrosion control, are now being replaced by non-chromate formulations, such as molybdate salts. Certain molybdate salts have been found to have equal or superior corrosion inhibition properties. Molybdenum is an element which is considered to have a low order of toxicity and considerably less environmental impact than other heavy metals such as chromium. Other alternative corrosion inhibition chemicals including poly-phosphates, and phosphorates have also replaced chromate based formulations. Phosphates and phosphate derivatives are considered potentially problematic in that they promote algae growth at elevated concentrations.

In cooling water systems, chlorine has been traditionally used as an algicide/bactericide. Chlorine reacts with ammonia, nitrogen and phenols in cooling water systems to produce potentially toxic chloramine and chlorinated phenolics. Chlorine is now slowly being replaced by alternative halogen chemical treatments such as bromine, and brominated hydrocarbons. Elevated concentrations of bromine/bromides may also result in toxic effluents.

Ozonation is a promising new technology for the replacement of chlorination and addition of other non-oxidizing biocides. Some U.S. Linde facilities are experimenting with ozonation to replace all other chemical additives to the cooling tower recirculation water. Tests have shown that ozonation of cooling tower make-up water caused the formation of copper and zinc oxides which resulted in a need to adjust flow and cycles of concentration (Ref. 2). Until this technology is demonstrated to be practically applied to cooling tower systems, ozonation for comprehensive cooling tower treatment will not be recommended as a general technology.

Selection of alternative water conditioning chemicals is dependant upon the system conditions including:

- Intake water chemistry
- Heat exchanger design
- Materials of construction
- Operating conditions
- System contaminants
- Environment effluent considerations (Ref. 4).

Re-examination of Table 1 suggests that there are not many facilities which warrant changes in their water treatment chemicals. If the effluents are toxic at facilities where no additive information was provided, and no other sources of toxicity have been identified, the formulation of the water conditioning chemicals should be examined. If alternatives are sought, it should be noted that water treatment chemicals are highly specific to the nature of the system, and selection of alternative chemicals will undoubtedly introduce other contaminants. The new parameters and conditions introduced with the implementation of a new water conditioning chemical system should be carefully evaluated, before a change is made in the existing system.

3.0 COST

It is difficult to provide an estimate of costs for the above described changes since applications will vary greatly from one facility to another. Costs will depend on the size of the system involved, chemicals used, chemical dosages, equipment requirements, and the materials of construction.

Below is an estimate of the cost ratios for various water conditioning chemical types provided by Betz Inc.

Chemical Type	Cost Ratio
Chromate	1
Zinc-Organic	2
Phosphate	2
Molybdate	3 to 6

These cost ratios should be considered carefully, since program costs may be reduced by increasing the cooling system cycles and, since the chemical requirements are highly specific to each system's capabilities. For one user, a change in chemical might result in a 100 percent cost increase, while for another, it might be only 20 percent (Ref. 3).

4.0 OTHER ISSUES

The quality of boiler and cooling tower blowdown may also be affected by other factors including:

- Quality of the raw water source.
- Corrosion of the materials of construction.

Raw Water Source

If the quality of the intake water is poor, a poor effluent quality is inevitable, without either pretreatment of the intake water, or end-of-pipe treatment. If an alternative water source is not feasible, pre-treatment is preferred to end-of-pipe treatment. Some pre-treatment technologies, apart from chemical addition, include filtration, and ion exchange. Backwashing, and particularly regeneration procedures can result in elevated concentrations of contaminants in effluent streams. The frequency of backwashing may be altered such that the TSS in the effluent does not exceed 50 mg/L to minimize potentially lethal effects. Alternatively, if TSS levels are a concern, settling may be used to remove solids prior to discharge (Ref. 5), or the backwash could be directed to drying beds.

Chemical formulations which have been used to clean make-up water ion exchange resin beds and condensate polisher beds are being modified to eliminate potential toxic compounds generated in the cleaning and rinse waters from these operations. Compounds used in the past in this service generally contained organic acids combined with surfactants which eventually becomes part of a plant is wastewater stream. New techniques such as ultrasonic cleaning using non-toxic chemicals have been developed for cleaning resin beds.

Corrosion of Materials of Construction

Corrosion of the materials of construction of boiler and cooling towers systems has resulted in a progression towards more costly, corrosion resistant metals. Copper-bearing alloys, have been avoided in heat exchanger equipment, but may still exist in non-heat exchanger service within the systems. If the copper from these non-heat exchanger sources corrodes, it can plate out on carbon steel equipment, which initiates rapid pitting from galvanic cell-type reactions (Ref. 4). As a result, copper and copper alloys have been changed to corrosion resistant steel alloys and/or use of protective coatings, thereby eliminating the contaminants in boiler blowdown and steam condensate streams.

Below is an estimate of the cost ratios for various construction materials:

Material of Construction	Cost Ratio
• Carbon steel -	1
• Copper alloy (cupronickel) -	1.5
• Stainless steel -	2.5
• Titanium alloy -	6.0

5.0 SUMMARY

Water conditioning chemicals added to boiler and cooling tower make-up water, concentrate during the operation of these systems, resulting in potentially toxic blowdowns. Rather than implementing end-of-pipe treatment, the preferred method to minimize or avoid toxic effluents is to use alternative water conditioning chemicals. However, the selection of water treatment chemicals is highly specific to the nature of the system, and alternative treatment chemicals, will introduce different contaminants to the system. The net results including cost, performance and environmental impact of new conditioning chemicals must be carefully assessed before a change is made.

As well, the raw water source should be selected with care to avoid the need for excessive treatment (which may result in potentially toxic discharges) and the materials of construction should be selected to avoid corrosive metals. In summary, water treatment chemicals, raw water and materials of construction should be selected so that the net loadings of "Priority 1" contaminants in the effluent are minimized.

6.0 REFERENCES

1. Irwin, Bob. Dearborn Chemical Company Limited, Telephone and telefax communication and personal correspondence. September/October 1991.

2. Fletcher, Randy. UCIG Tonawanda, Telephone and telefax communication. August 1991.

3. Beauté, Christian. Betz Inc., Telephone and telefax communication and personal correspondence. August/September/October 1991.

4. Grier, J.C. and Ken, E.F. Better Water Treatment in Cooling Tower System, from "Safety in Air and Ammonia Plants". A.I.C.E., 1978.

5. General Technology Report, Sedimentation for TSS Removal.

6. Koniuch, Ron. Sulco Chemicals Limited. Telephone conversation. November 1991.

APPENDIX

Table

Table A1
Water Treatment Chemical Usage for Boiler and Cooling Tower Make-up Water

Facility	Water Use	Flow (m^3/d)	Additives	Primary Contaminants of Concern[2]
Allied Chemical Canada Ltd.	Cooling tower make-up	Not available	• Betz 45	• Chromium[3]
Cabot Canada Ltd.	Boiler make-up	Not available	• Caustic Soda • Amerplex 705 • Amercor Mark III	• None identified
Cyanamid Canada Inc. (Maitland)	Boiler make-up	28.8	• Ferrous sulphate • Betz C-68 • Betz J-12	• Sulphate • Not Available • Not Available
Explosives Technologies International	Boiler make-up	Not available	• Not Available	• Not available
ICI Nitrogen Products	Cooling tower and boiler make-up	480	• Not Available	• Not available
ICI Forest Products	Cooling tower make-up	Not available	• Alchem 71-D-5 • Alchem 81-C-09 • Alchem 7330 • Alchem 8365 • Ambertite IRA-402 • Anderson RC-30 • Sodium hypochlorite • Sodium hydroxide	• None identified • None identified • None identified • None identified • None identified • None identified • Chloride • None identified
Liquid Carbonic Inc., Maitland	Cooling tower make-up	Not available	• Betz C-63P • Betz MS-120 • Betz J-12 • Betz 35106 • Betz K-1-2	• Bromine/Bromide • Not available • Not available • Phosphate/phosphate derivatives • Not available
Nitrochem	Cooling tower and boiler make-up	Not available	• Dearborn 657 • Dearborn 698 • Dearborn 66 • Dearborn 817 • Dearborn AM96 • Dearborn 17 • Sanfax BG26	• Phosphate/phosphate derivatives • Phosphate/phosphate derivatives • Not available • Not available • Not available • Not available • Not available
Linde, Moore Township site	Cooling tower make-up	12	• Dearborn 735 • Dearborn Poly-E1-PH905	• Bromine/bromide • Phosphate/phosphate derivatives
Linde, Sarnia site	Cooling tower make-up	46.6	• Dearborn 735 • Dearborn Poly-E1-PH905 • Bird-Archer 3057	• Bromine/bromide • Phosphate/phosphate derivatives • Not available
Puritan-Bennett	Cooling tower make-up	Not Available	• Dearborn 717 • Dearborn 702	• None identified • None identified

Table A1 (Cont'd)
Water Treatment Chemical Usage for Boiler and Cooling Tower Make-up Water

Facility	Water Use	Flow (m^3/d)	Additives	Primary Contaminants of Concern[2]
Sulco	Cooling tower and boiler make-up	68.1	• Dearborn 817 • Dearborn 4085 • Dearborn 4463[4] • Chlorine • Dearcide 702 • Dearcide 700 • Alkameen	• Phosphate/phosphate derivatives • Not available • Zinc • Chlorine/chloride • None identified • None identified • None identified
Linde, Sault Ste. Marie Site	Cooling tower make-up	672	• Dearborn 546 • Dearborn 726 • Poly-E1-PH905 • Dearcide 747	• Chlorine/chloride • None identified • Phosphate/phosphate derivatives • Molybendum

Notes:

1. Only facilities where blowdown is discharged directly are included here.
2. Primary contaminants of concern identified include: chromate/zinc, phosphates, chloride and bromide.
3. Information provided by Allied Chemical Canada Ltd.
4. Dearborn 4463 was exchanged for a phosphate-based treatment chemical mid-way through the MISA Monitoring Regulation period (Ref. 6).

TECHNOLOGY REPORT
CYCLONE SEPARATORS FOR SUSPENDED SOLIDS REMOVAL FROM BOILER BLOWDOWN

1.0 DESCRIPTION

A cyclonic separator uses inertial forces to remove solids suspended in a third medium. Liquid with solids entering the unit forms a vortex and particulates in the water stream, because of their inertia relative to the liquid stream, tend to move toward the outside wall. They drop from the wall inside of the cyclone, to an external receiver for eventual disposal.

2.0 APPLICATIONS

Cyclone separators have previously been used to remove solids from water streams in water supply (river/lake) applications and in mining and mineral processing operations where there is a significant concentration of large particles in the water stream. They have also been extensively used in the pulp and paper facilities to clean pulp and paper stock slurries.

For boiler blowdowns, specially designed separators/heat recovery units have been developed to separate water and solids and recover flash steam in a single unit. The separator takes heat out of the blowdown steam and recovers it in the boiler make-up water, and reduces drain temperature to 38 to 43 °C. With the flash separator, 100 percent of the heat in the flash steam is recovered. This is not the case if the blowdown is simply dumped to a hot well or a blowdown tank.

In general, cyclone separators are best suited for applications where the water or wastewater stream contains a high level of larger particles, where the cyclone separator is coupled with other devices such as filters which are more suited to remove fine particles, and in the treatment of boiler blowdown where heat recovery is a prime consideration. Special devices based on cyclone principle have been used with success in this latter application.

3.0 ONTARIO APPLICATIONS

Cyclone separators can be considered for the removal of suspended solids from streams such as boiler blowdown, cooling tower blowdown and water filter and softener backwash. The technology would be most suitable for boiler blowdowns.

For streams such as cooling tower blowdown, and water filter and softener backwash, physical/chemical processes such as clarification and filtration have been more popular for suspended solids removal because of their capability to remove both large and finer solids. Cyclone separators are most efficient in removing larger particles and therefore are limited in their applications.

4.0 DESIGN INFORMATION

The design/capacity of a cyclonic type separator will depend on a number of variables such as liquid flow rate, temperature, pressure, size and density of suspended material, pressure drop across unit, inlet suspended solids level and degrees of classification required.

For boiler blowdown applications, one manufacturer of a speciality separator (Ref. 1) provides units ranging in capacity from 980 to 9,800 m^3/d. Where larger capacities are required, multiple units are used.

Boiler blowdown separators are usually constructed of carbon steel. Internal heat exchange coils are copper or stainless steel.

5.0 PERFORMANCE

Cyclones can remove larger particles but will operate with reduced efficiency for smaller particle sizes. Collection efficiency drops off rapidly as the particle size decreases. Typically, a cyclone separator will be effective for particles down to 15 microns.

One potential problem in the use of cyclones is the reluctance of certain collected particulates to drop from the cyclone wall. This condition, agglomeration, can occur if particles are fibrous or sticky. For this reason, use of cyclones on streams containing oily solids is not recommended.

6.0 OPERATING REQUIREMENTS

Low pressure cyclone separators typically operate with a pressure drop of 70-100 kPa between the feed and liquid outlet. Electrical power would be required for the inlet feed pump (except in the case of boiler blowdown). Separated solids may require further dewatering prior to disposal. The separator has no moving parts so that maintenance of the unit is manual. Periodic cleaning of the separator would typically be once per year.

7.0 CAPITAL COST

Typical costs for boiler blowdown separators are as follows:

Capacity of 980 m^3/d	-	\$3,900 to \$7,700
Capacity of 9,800 m^3/d	-	\$19,000 to \$29,000

Costs included 35 percent installation, 30 percent estimating contingency, 15 percent engineering and 7 percent G.S.T. (ENR CCI 6343).

8.0 OPERATING COST

Operating costs for a cyclone separator are minimal. Electrical power is consumed by the feed pump (not required in case of boiler blowdown) and a yearly maintenance/cleaning of the separator is typically required.

9.0 REFERENCES

1. Vendor Information, Penn Flash Economizer, Pennsylvannia Separator Company, Brookville, PA.

2. Engineering News Record Construction Cost Index for Toronto, March, 1991.

TECHNOLOGY REPORT
OIL AND GREASE REMOVAL BY ABSORPTION

1.0 DESCRIPTION

For small streams containing low concentrations of oil and grease, an alternative to gravity oil/water separation methods involves the use of a granular sorbent material such as KLENSORB^R in a fixed bed contractor vessel, similar to activated carbon. The exhausted absorbent cannot be regenerated but can be disposed of by incineration along with absorbed oil (or by landfilling).

The sorbent material reportedly has an oil absorptive capacity up to 60 weight percent.

2.0 APPLICABILITY

KLENSORB^R has been used as a replacement for, or as a supplement to, activated carbon adsorption as an oil in water polisher prior to ion exchange or other water treatment processes susceptible to oil and hydrocarbon fouling. Typical KLENSORB^R applications include:

- Recovery of low pressure steam condensate
- Treatment of gasoline contaminated groundwater
- Treatment of wastewater
- Oil polishing from ultra filtration systems
- Protection of reverse osmosis, desalination, or ion exchange units
- Protection from oil spill intrusions

3.0 ONTARIO APPLICATIONS

The technology is applicable to low flow air compressor condensate streams potentially contaminated with low levels of oil (10-50 mg/L). For this application (i.e. relatively low flows and low oil contamination), KLENSORB^R and other disposable sorbents may offer cost advantages over other oil removal processes.

4.0 DESIGN INFORMATION

The design criteria for KLENSORB^R system is similar to a typical granular activated carbon system. The following design parameters are recommended by the supplier:

- Bed Depth - 1 m (min.)
- Hydraulic Loading - 7.3 to 9.8 $m^3/m^2.h$
- Contact Time - 15 minutes (min.)
- Backwash Rate - 29 m3/m2.h at 27 °C
- Bed Expansion - 20 percent

Mechanical features for KLENSORB^R filter system should include:

- Suitable underdrain to assure uniform water flow throughout the KLENSORB^R bed.

- Where required, packed gravel around underdrains for applications involving infrequent KLENSORB^R replacement and high oil loading.

- Adequate free board to allow for proper bed expansion if backwash capability is necessary. (Note: Bed expansion caused by oil retention in the spent KLENSORB^R is negligible).

- Access for potential vacuum removal of spent KLENSORB^R.

5.0 PERFORMANCE

A full scale test employing KLENSORB^R to treat and recycle oily condensate in a petrochemical plant reportedly yielded an average effluent oil concentration of approximately 0.3 mg/L with an average influent of 6 mg/L. The effluent oil concentration was apparently at or below the detection limit (0.1 mg/L) for 45 percent of the test period.

The maximum effluent oil concentration observed was reportedly 2.7 mg/L when the influent concentration exceeded 50 mg/L. For air compressor condensate containing 10 to 15 mg/L, effluent oil levels will, in most cases, be less than 1 mg/L. KLENSORB^R is not normally recommended for cases where high oil concentrations (> 50 mg/L) are present since the life of the material is principally a function of the total amount of oil removed. In these cases, a gross oil removal device (i.e. stream tank, plate separator etc.) is required to remove the bulk of the oil. Likewise high levels of suspended solids in the influent would affect performance of the KLENSORB^R unit. More frequent backwashing would be required resulting in larger volumes of wastewater for disposal.

For an air compressor condensate stream of 3 m^3/d and containing 15 mg/L oil, a KLENSORB^R column 0.3 m in diameter with 1 m bed would have a theoretical capacity of over two years.

6.0 OPERATING REQUIREMENTS

Spent material is commonly disposed at either an appropriate landfill facility or through incineration. The composition of KLENSORB^R has a fuel value of some 32,600 kJ/kg which is comparable with many grades of bituminous coal.

Backwashing of a KLENSORB^R column using water may be required to remove filtered solids from the surface of the media bed if solids are present in the influent.

7.0 CAPITAL COST

The cost of the sorbent material itself is in the order of $7 to $9 per kg. A small fixed bed contactor (approximately 0.3 m diameter and 1.5 m straight side) to treat 2 to 3 m^3/d flow with backwashing facilities will cost approximately $23,000 to $31,000, including 35 percent installation, 15 percent engineering, 30 percent estimating contingency and G.S.T. (ENR CCI 6343).

8.0 OPERATING COST

On-going operating costs include the following:

- Sorbent replacement at $7 to 9 per kg of material and disposal of spent material.

9.0 REFERENCES

1. Vendor Information, Calgon Carbon Corporation, Pittsburgh, PA, KLENSORB^R Application Bulletin.

2. Engineering News Record Construction Cost Index, for Toronto, March 1991.

TECHNOLOGY REPORT
MERCURY SPECIFIC ION EXCHANGE RESIN

1.0 DESCRIPTION

An alternative to sulphide precipitation for mercury removal involves the use of a mercury-specific ion exchange resin, developed by Akzo Zout Chemie, Delefijl in the Netherlands. This approach is referred to as the Akzo Imac TMR Process. This process is apparently widely used in Europe and elsewhere in the world but has not penetrated the North American market with the exception of its use at a Monsanto, U.S. facility in the late 1970s (Monsanto is no longer a chlorine producer).

Akzo developed the process for its own use and has contracted with Tebodin Consulting Engineers to sell the technology to others. The Imac TMR resin used in the process is also sold by Rohm & Haas as Duolite GT-73, and Sybron Chemicals manufactures a SR-4 resin which appears to be equivalent. In addition, Mitsubishi Chemical Industries claims to market an equivalent product through its subsidiaries residing in Europe and Dianex in North America. The references in Section 9 list several reports and articles on mercury specific resin applications.

The ion exchange unit which contains the resin is typically of metal fabrication and cylindrical in shape. It may also be fitted with a simple spray mechanism used for backwashing of the unit. The most common configuration for the operation of ion exchange units is fixed bed, countercurrent flow. In this operating mode, wastewater is passed through the resin bed in a direction opposite to be backwash, regeneration liquid and rinse water flows. The use of multiple beds may provide continuous service and requires the use of only one regeneration system.

2.0 GLOBAL APPLICATIONS

In Europe, the mercury specific ion exchange resin system is used as a primary treatment for mercury removal from cell room wastes. The regeneration of the resin with hydrochloric acid recovers the mercury, which is recycled back to the electrolysis plant and used to acidify the brine, whereby mercury is returned to the chlorine plant. Table 1 presents a list of facilities that were using this process in 1979. Figure A1 presents a flow schematic of the ion exchange process.

Using the ion exchange resin for primary mercury treatment, the following process steps are necessary:

Table 1
Imac TMR Project Information Sheet

Company	Site/Country	Treatment	Capacity (m^3/h)	Start-Up
AZC	Delfziji	Waste water	15	1973
AZC	Hengelo	Waste water	5	1978
AZC	Rotterdam	Waste water	15	1976
ECI	Germany	Waste water	15	1975
Norsk Hydro	Norway	Waste water	10	1975
Norsk Hydro	Norway	Brine	2	1975
Borregaard	Norway	Waste water	15	1976
Dynamit Nobel	Germany	Waste water	15	1977
Ciba Geigy	Switzerland	Waste water	5	1977
BP	Great Britain	Waste water	7.5	1979
SNEP	Morocco	Waste water	10	1977
Kymene Oy	Finland	Waste water	6	1977
PanAmerica	Brazil	Waste water	4	1979
Monsanto	U.S.A.	Waste water	35	1979
C.I.	Cuba	Waste water	6	1979
Snia Viscosa	Italy	Waste water	9	1979
Anic	Italy	Waste water	15	1979
Anic	Italy	Brine	60	1979

- Flow equalization
- Oxidation, pH adjustment
- Filtration
- Two stage dechlorination, using sodium bisulphite ($NaHSO_3$) or sodium sulphite (Na_2SO_3).
- Granular activated carbon filter adsorption
- Ion exchange.

The ion exchange resin has also been demonstrated to be effective for tertiary removal of mercury following sulphide precipitation.

The LCP Chemicals Company, Solvay, New York plant, which was closed in June 1988, is currently undergoing facility decommissioning and site remediation. LCP used a sulphide precipitation process when the plant was operating and reported effluent concentrations of 30 µg/L mercury when the system was operating well. The plant treated about 1,363 m^3/d of cell room wastewater. They are currently using the sulphide precipitation system for mercury removal from contaminated groundwater, and polishing the treated effluent with the Rohm & Haas GT-73 mercury specific ion exchange resin.

The Occidental Chemical plant in Muscle Shoals, Alabama, which uses a hydrazine reduction process for mercury control, is also in the engineering phase for adding an ion exchange polishing unit. They currently treat between 380 and 570 m^3/day of cell room wastewater and expect to install the ion exchange unit in late 1991.

The tertiary treatment system is applicable over a full range of flow rates, and has been demonstrated effective for treating effluents from the sulphide precipitation process. Figure A2 presents a flow schematic of the tertiary treatment process.

3.0 ONTARIO APPLICATION

Only one mercury cell chlor-alkali production facility, ICI (Cornwall), is included in the Ontario Inorganic Chemical Sector. Cell room wastewater is currently treated by sulphide precipitation followed by filtration and activated carbon adsorption. Since a primary wastewater treatment facility already exists at the Ontario plant, the tertiary treatment system will be considered as an option for the cell room wastewater stream.

4.0 DESIGN INFORMATION

Table 2 presents design information provided by Akzo and Rohm & Haas for the ion exchange resin.

At the LCP plant, a Rohm & Haas GT-73 resin is used in an ion exchange unit designed to treat 270 m^3/d of effluent from their sulphide precipitation/filtration process. Their system has the following design:

• Resin	0.3 m^3
• Flow rate (volume of effluent per volume of resin per h)	38 h^{-1}
• Bed depth	1.2 m
• Flow rate	0.8 m/min

Table 2
Design Information on Mercury Specific Ion Exchange Resins

Parameter	AKZO	Duolite GT-73[1]
Flow Rate (volume effluent per volume of resin per hour)	10 m/h	5-20 m/h
Bed depth	1.2-1.7 m	0.5-1.75 m
pH	1-14	-
Pressure drop at flow rate of 10 m/h	0.1-0.2 m	-
Temperature of effluent	<80 °C, preferably <40 °C	-
NaCl concentration	Any concentration	-
Operating capacity	-	300-1,000 meq/L
Backwash flow rate	-	10-12 m/h

Note:

1. Formerly known as Imac TMR and Imac GT-73.

5.0 PERFORMANCE

Akzo Zout Chemie guarantee to their licensees an effluent mercury concentration of 0.005 mg/L. LCP Chemicals was issued an effluent discharge permit by the U.S. EPA in May 1991, that limits total mercury to a concentration of 5 μg/L on an average daily basis, or a total loading of 0.0004536 kg/d. They estimated the influent concentration to the ion exchange process at 30 to 50 μg/L.

6.0 OPERATING REQUIREMENTS

The time interval between regeneration of the resin can vary between one month to one year, depending on the amount and composition of wastewater, the resin age and operation. Figure 3 shows the relationship between capacity of the resin and mercury concentration in the wastewater. This relationship applies to fresh resin and shows that at a mercury concentration of 10 mg/L in wastewater, the resin can absorb as much as 100 g mercury per litre of resin before it requires regeneration. This means that 10,000 m^3 of such wastewater can be treated with 1 m^3 of resin before regeneration

LCP Chemicals have calculated a six year life for their resin without regeneration, because of the relatively low influent concentrations resulting from upstream precipitation. The resin is generated with hydrochloric acid.

Chemical damage to the resin is expected in the form of oxidation of - SH groups. This can result from oxidizing agents such as chlorine and other strong oxidants in the presence of ferric ions. If the oxidizing reaction with the resin is caught before it becomes irreversible, the resin can be reactivated with a proprietary reactivation procedure also offered by Akzo Zout Chemie. Dechlorination ahead of ion exchange helps to mitigate these effects.

Apart from regeneration and possible reactivation, the only operating requirements are labour and energy associated with operation of the system. At all chlor-alkali plants, hydrochloric acid is readily available for regeneration.

7.0 CAPITAL COSTS

A fixed bed, countercurrent ion exchange unit would cost approximately $790,000 to $890,000 (including $40,000 for resin) based on the following:

- Wastewater flowrate = 230 m^3/d.
- Influent mercury levels: 140 $\mu g/L$.
- Fittings for regeneration system included.
- Waste storage tanks, etc. not included.
- Installation at 35 percent, engineering at 15 percent, estimating contingency at 30 percent and 7 percent G.S.T. included.
- ENR CCI (Toronto) at 6343.

Unit costs quoted for mercury specific resins (including G.S.T.) are:

- Rohm & Haas Duolite GT-73
    - 0.2 - 1.1 m^3: $22,800/$m^3$ (1991)
- Sybron SR-4
    - 0.02 - 0.2 m^3: $18,600/$m^3$ (1991)
    - 0.82 - 2.8 m^3: $17,000/$m^3$ (1991)

8.0 OPERATING COSTS

It is anticipated that ion exchange at ICI (Cornwall) will not require frequent regeneration. When required, hydrochloric acid will be readily available onsite and recycled back to the process after regeneration. In addition, labour and energy costs should be negligible in comparison to those already associated with wastewater treatment.

9.0 REFERENCES

1. Akzo Letter, July 26, 1991.

2. Akzo brochure, "The Akzo Imac TMR process for the removal of mercury from waste water".

3. "Some New Developments in the Field of Mercury Pollution Abatement by Akzo" Ir. C.J.N. Rekers Akzo Zout Chemie Nederland B.V. Paper presented at 16th Meeting of The Chlorine Institute, Plant Managers, Seminar, Houston, TX, February 7, 1973.

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APPENDIX

Figures

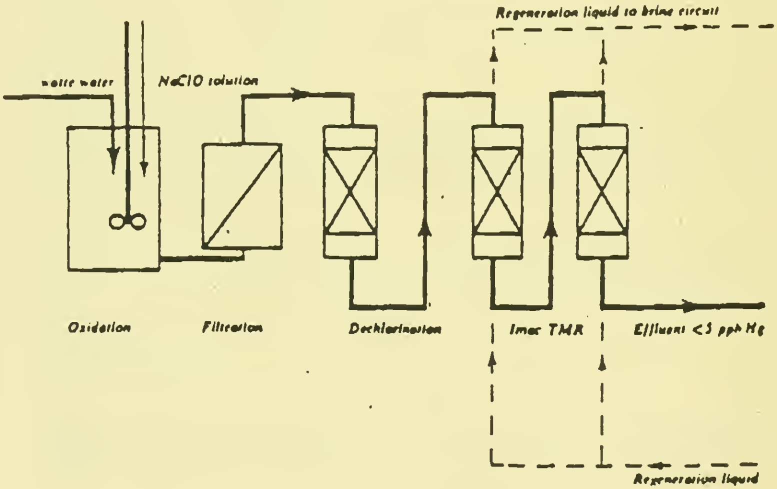

Figure A1
AKZO IMAC TMR PROCESS

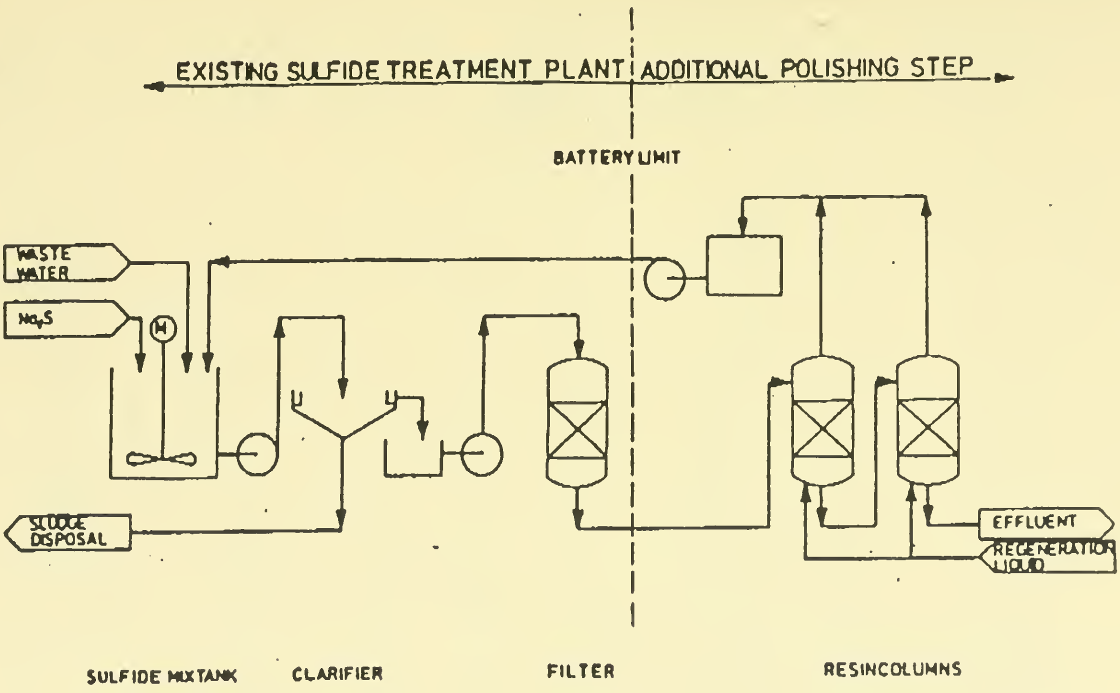

Figure A2

POLISHING STEP AFTER EXISTING SULFIDE TREATMENT

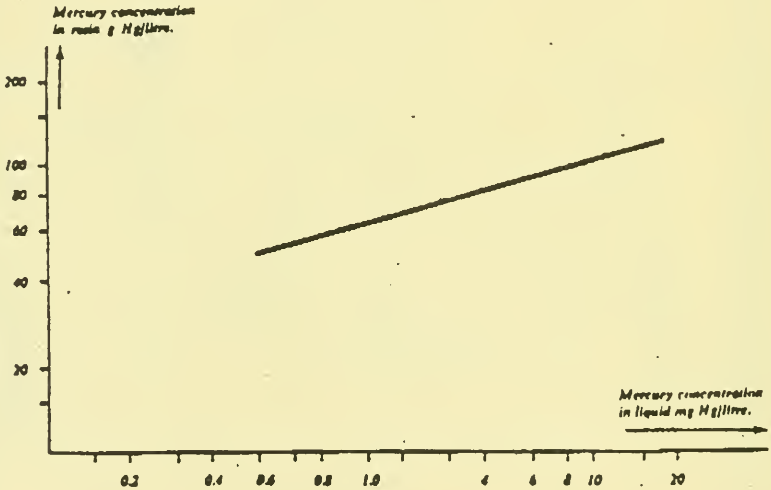

Figure A3

EQUILLIBRIUM

CURVE OF IMAC TMR

TECHNOLOGY REPORT
BIOLOGICAL NITROGEN REMOVAL

1.0 DESCRIPTION

Biological nitrification is the two step oxidation process resulting in the conversion of ammonium (NH_4) to nitrate (NO_3). The process is completed primarily by two general of microorganisms: Nitrosomonas and Nitrobacter. The overall reaction of the nitrification process is as follows:

$$22\ NH_4^+ + 37\ O_2 + 4\ CO_2 + HCO_3^- \rightarrow C_5H_7NO_2 + 21\ NO_3^- + 2\ H_2O + 42\ H^+$$

Cell matter is produced by the nitrification process. Approximately 4.2 mg of oxygen is consumed by the nitrification process for each mg of ammonium converted.

Denitrification is the process by which microorganisms reduce nitrate ion to nitrogen, nitrous oxide or nitric oxide. Under anoxic conditions, nitrate dissimilation occurs through a series of reactions catalyzed by specific enzymes, according to the following equation:

$$NO_3 + 1.08\ CH_3OH + H^+ \rightarrow 0.065\ C_5H_7O_2N + 0.47\ N_2 + 0.76\ CO_2 + 2.44\ H_2O$$

Nitrification and denitrification may be achieved in a number of biological process configurations that are generally classified as suspended growth, fixed film or hybrid processes.

2.0 GENERAL APPLICATION

Nitrification and denitrification have been demonstrated at municipal wastewater treatment plants, where influent ammonia concentrations range from approximately 15 to 25 mg/L.

Biological nitrogen removal has also been successfully used to treat wastewater from industries such as synthetic rubber, pulp and paper, pharmaceutical, petroleum refinery and tanning, with influent ammonia concentrations ranging from 30 to 700 mg/L (Ref. 1)..

At one nitrogen fertilizer in the U.S., aerobic and anaerobic lagoons are used to reduce nitrogen levels from 150 to 200 mg/L by up to 98 percent (Ref. 2). Methanol is added as a carbon source to the denitrification lagoons. Biological treatment has also been used on coke plant wastewater containing up to 3,000 mg/L of free/fixed ammonia, cyanide and thiocyanate, in a full scale facility at a steel plant in Orem, Utah (Ref. 3). Pilot scale studies carried out by Environment Canada have shown removal efficiencies greater than 90 percent for total nitrogen, as well as phenolics, thiocyanate, total cyanide and suspended solids in a nitrification-denitrification system treating coke plant wastewater combined with blast furnace scrubber blowdown (Ref. 4).

3.0 ONTARIO APPLICATIONS

Biological nitrogen removal is being considered for effluent and in-plant wastewater streams generated in Ontario Inorganic Chemical sector plants. Streams with organic, ammonia and nitrate concentrations above 20 to 30 mg/L on a consistent basis will be considered for treatment.

4.0 DESIGN INFORMATION

As discussed in Section 1.0, several types of nitrification and denitrification systems can be utilized to achieve the same levels of treatment. For the purposes of providing order-of-magnitude cost estimates for implementation of biological treatment at selected Ontario Inorganic Chemical Sector Plants, one type of process was examined. The biological fluidized bed process, illustrated in Figure A1, is discussed in the following sections, with respect to capital and operating requirements and costs.

The high intensity biological fluidized bed treatment process is a novel fixed-film short hydraulic retention time (HRT) system. It has been developed as a modification of more conventional fixed film biological systems, such as the trickling filter, packed bed reactor or rotating biological contractor (RBC), for carbon oxidation, nitrification and denitrification of municipal and industrial wastewater. A secondary clarifier is not generally required.

The basic biological fluidized bed treatment concept involves passing a wastewater upward through a bed of granular media such as sand at a velocity sufficient to expand the bed beyond the point at which the frictional drag is equal to the net downward force of gravity. The upflow velocity of the liquid phase produces a fluidized state of motion in the granular bed. A population of microorganisms is developed as an attached film on the surface of the fluidized media. The support media provides a very large surface area (3,000 to 4,000 m^2/m^3) for biomass growth, resulting in reactor biomass concentrations up to an order of magnitude higher than characteristic of conventional suspended growth processes.

Since the early 1970's, potential advantages of the biological fluidized bed process have been reported. Numerous researchers have become involved in the evaluation of the technology for the treatment of potable water as well as domestic and industrial wastewaters. All the basic biological treatment processes including carbon oxidation, nitrification and denitrification have been assessed. The process has been evaluated in the anaerobic, anoxic, aerobic and oxygenic (using pure oxygen) operating modes.

The principal advantage of the biological fluidized bed process, compared to conventional biological systems, is the reduced reactor volumes necessary to achieve a similar degree of treatment. The high volumetric conversion efficiencies characteristic of fluidized bed processes are a direct result of the high biomass concentration achievable in these reactors. Biomass concentrations of 10 to 15 g VSS/L have been achieved in fluidized bed reactors operated for carbon oxidation and combined carbon oxidation-nitrification. For denitrification, biomass concentrations in the range of 20 to 40 g VSS/L have been reported. These high biomass concentrations can result in up to an order of magnitude reduction in the reactor hydraulic retention time (HRT) necessary to effect a given degree of treatment. In addition, the fixed film nature of the fluidized bed process can eliminate the need for secondary clarification of the wastewater in many instances.

Table 1 presents typical design parameters for a fluidized bed nitrification-identification system.

Table 1
Design Parameters for Nitrification-Denitrification Using Fluidized Bed System[1]

System	Parameter	Value
Aerobic nitrification reactor	HRT	14 h
	SRT	70 d
	Recycle ratio	50%
	Biomass concentration	15 g VSS/L
	Typical NH_3-N loading	0.01-0.03 g/g VS/d
	Theoretical O_2 requirement	4.2 mg O_2/mg NH_3-N
Anoxic denitrification reactor	HRT	2 h
	SRT	10 d
	Recycle ratio	8:1
	Biomass concentration	25 g VSS/L

Notes:

1. Based on pilot scale design for treating coke plant wastewaters (Ref. 4).

Effluent polishing might be needed depending on effluent standards and expected process removal rates. Suspended solids removal may be provided by means of polymer addition to a conventional flocculator clarifier designed at a conservative hydraulic loading (e.g. 40 $m^3/m^2/d$).

4.0 PERFORMANCE

Final effluent characteristics achievable by the biological fluidized bed reactor will largely depend on influent characteristics. Table 2 presents a summary of performance achieved in two systems treating coke plant wastewaters.

Table 2
Reported Performance for Nitrification Denitrification Systems Treating Coke Plant Wastewater

Parameter	Study 1[1]			Study 2[2]		
	Influent Conc. (mg/L)	Effluent Conc. (mg/L)	Removal Efficiency (%)	Influent Conc. (mg/L)	Effluent Conc. (mg/L)	Removal Efficiency (%)
Ammonia-N	196	1.3	99.4	2,179	15	99.3
TKN	247	11.9	95.2	-	-	-
Nitrate & Nitrite-N	-	4.6	-	-	10-30	-
Filterable Organic Carbon	700	56	92	-	-	-
COD	-	-		-	600	89.6
Phenolics	413	0.16	>99.9	-	-	-
Thiocyanate	346	2.4	99.3	2	0.0	>99.9
Total Cyanide	8	6.1	23.8	37	3.3	91

Notes:

1. Ref. 4.
2. Ref. 3.

5.0 OPERATING REQUIREMENTS

Theoretically, air could be used to supply the requirements of the process. High oxygenator pressures would be necessary to dissolve the oxygen required at normal and maximum ammonia loading conditions. These operating pressures may result in excessively deep oxygenator pits for the design. In addition, the presence of nitrogen in the liquid phase could interfere with oxygen transfer and the possible release of nitrogen gas within the fluidized bed reactors could adversely affect biofilm adhesion. Therefore, the supply of pure oxygen to the nitrification reactor is suggested. Where pipeline oxygen is not available, alternatives include the purchase of bulk liquid oxygen or on-site production.

The nitrification process reduces alkalinity. Alkalinity consumption during nitrification is important because nitrifying organisms are efficient only over a relatively narrow pH range. At the same time, denitrification is a net producer of alkalinity. The production of alkalinity will raise system pH and offset some of the loss of alkalinity from nitrification in a combined system. Additional alkalinity from an external source may be required based on influent characteristics.

As mentioned previously, an additional source of carbon should be provided to achieve denitrification. The denitrification process involves the conversion of nitrate and nitrite ions into nitrogen gas by facultative heterotrophic bacteria. An energy source is required for this, and methanol has been widely used as an external carbon and energy source due to its high denitrification rate, abundance of supply and low sludge solids yield. Because of high methanol prices, alternative carbon sources for denitrification have been considered (Ref. 5).

Sludge disposal and chemical costs will depend on the sludge yield of the carbon source used and the effluent characteristics.

6.0 CAPITAL COSTS

Preliminary capital cost estimates for a coupled biological fluidized bed process including a flocculator-clarifier for effluent suspended solids removal treating coke plant wastewater at approximately 1,300 m^3/d are summarized in Table 3 (Ref. 4).

Table 3
Capital Cost Estimates for Coupled Biological Fluidized Bed Process Treating Coke Plant Wastewaters[1]

Item	Cost[2,3]
1. Equipment, instrumentation and engineering for two 9.8 x 6.1 m nitrification reactors, two 2.4 x 4.3 m denitrification reactors and 7.6 m diameter clarifier with polymer system.	$2,000,000
2. Concrete reactors, oxygenator pits, pump sumps and 7.6 m diameter x 3.7 m SWD clarifier basin.	$900,000
3. Pumps and prefab pump rooms.	$600,000
4. Piping and valves (erected basis).	$600,000
5. Installation of equipment, motor control centre, power wiring, site work.	$600,000
Total	**$4,700,000**

Notes:

1. From Ref. 4, 1984 prices scaled up to 1991. Costs include 35% installation, 30% contingency allowance, 15% engineering and 7% G.S.T.
2. ENR CCI 6343.
3. Based on the assumption of an available pipeline oxygen source. An additional capital cost or $2,000,000 would be required for a 2,700 kg/d pressure swing adsorption generation facility.

Cost estimates do not include pre-treatment processes, such as flow equalization, primary clarification or pH adjustment.

For estimating order-of-magnitude costs of a fluidized bed system for various flow capacities, the following formula can be used:

$$Capital\ Cost_2 = \left(\frac{Q_2}{Q_1}\right)^{0.6} (Capital\ Cost_1)$$

where:

Q = design flow capacity

7.0 OPERATING COSTS

Operating costs, including oxygen, electricity and chemicals for pH adjustment for treating coke plant wastewater were estimated at \$0.19 per m^3 of wastewater treated (1991). These costs were based on the availability of pipeline oxygen, and would increase to \$0.22/m^3 if bulk liquid oxygen were purchased, or \$0.17/m^3 if on-site oxygen production facilities were utilized.

Methanol requirements are estimated to be equal to about 3 kg/kg nitrate-N removed (Ref. 5). Current (1991) methanol prices are \$0.67 per kilogram.

Labour requirements will depend on the size of the plant.

Using methanol, approximately 0.6-0.9 kg sludge requiring disposal will be produced per kg of NH_3-N removed (Ref. 6). Current sludge disposal costs were estimated at \$50 per m^3, although these may vary widely depending on-site location and disposal method.

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APPENDIX

Figures

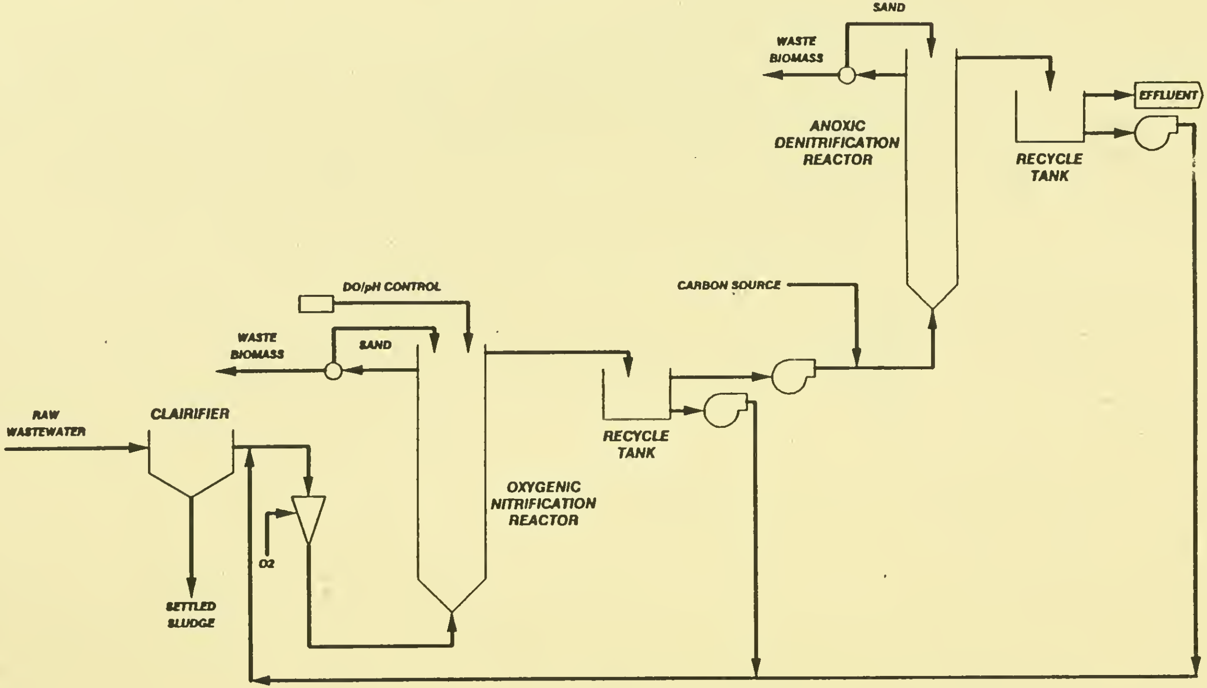

Figure A1
TWO-STAGE FLUIDIZED BED BIOLOGICAL TREATMENT SYSTEM FOR NITROGEN REMOVAL

TECHNOLOGY REPORT
DECHLORINATION

1.0 DESCRIPTION

Historically chlorine has been used as a disinfectant for raw water, in the removal of ammonia (breakpoint chlorination) from wastewater and more recently for zebra mussel control. Residual chlorine exerts toxicity on aquatic organisms and consequently it is desirable to dechlorinate effluents prior to discharge.

There are several common methods of dechlorinating wastewater, including:

- Treating chlorinated wastewater with sulphur dioxide gas.
- Treating the wastewater with sulphite containing compounds.
- Directing chlorinated wastewater through a granular activated carbon bed.

Some preliminary studies have been done utilizing hydrogen peroxide as a dechlorineting agent. However, these have met with limited success.

The use of granulated activated carbon absorbers is discussed in the General Technology Report, Granulated Activated Carbon (Ref. 1) since this technology may be used to remove other contaminants in addition to chlorine.

Treatment with sulphur dioxide gas and sulphite compounds removes free chlorine, monochloramine, dichloramine, nitrogen trichloride, and poly-n-chlor compounds. Some of the products of the reactions with chlorine include; bisulphite, sulphate, chloride, and a lowering of the pH. Some of the products of the reactions with chloramines include; chloride, sulphate, bisulphite, ammonium and a lowering of the pH.

Dechlorination using sodium metabisulphite solution is primarily used at facilities which require less than 45 kg of sulphur dioxide each day or where storage of sulphur dioxide is considered a hazard.

Schematics of solution and gas feed systems are presented in Figures A1 and A2.

2.0 ONTARIO APPLICATIONS

Dechlorination is applicable to streams at plants in the Ontario Inorganic Chemical Sector who chlorinate intake water, where chlorine is present as a result of the process, or where breakpoint chlorination is being recommended as a BAT option.

3.0 DESIGN INFORMATION

Sodium Metabisulphite System

For every gram of residual chlorine, 1.34 g of sodium metabisulphite is required. The solution storage and feed system includes the following components:

- A sodium metabisulphite solution storage tank with approximately one month storage capacity for 45 percent (expressed as sodium sulphite) solution.
- A motor driven chemical feed pump.
- A continuous dechlorination analyzer for sulphite residuals.
- A controller, to adjust chemical dosage rate based on dechlorination analyzer, and flow (if not constant rate).
- Pressure valves and chemical feed lines.

Sulphur Dioxide

Approximately 1 g of sulphur dioxide is required for every 1 g of residual chlorine. Sulphur dioxide is available in gas cylinders, ton containers, tank trucks or tank cars. The sulphur dioxide may be added to the wastewater stream as a gas or as a liquid.

Sulphur dioxide feed systems include:

- A remote vacuum sulphonator with gas flow control and injector.
- A continuous dechlorination analyzer for sulphur dioxide residuals.
- A controller to adjust chemical dosage rate based on dechlorination analyzer, and flow (if not constant rate).

4.0 PERFORMANCE

Zero residual chlorine is achievable with sodium metabisulphite or sulphur dioxide system.

5.0 OPERATING REQUIREMENTS

The operating requirements for the sodium metabisulphite dechlorination system includes restocking the sodium metabisulphite solution, and supplying a source of heat and electricity.

The operating requirements for the sulphur dioxide system includes a source of heat, and electrical power and replacement of the sulphur dioxide gas cylinders.

Both the dispensing systems should be checked at least once a month. Specifically, the amount of reagent in the analyzer should be checked and maintained. As well, both dechlorination systems should undergo a thorough maintenance check at least once a year.

6.0 CAPITAL COSTS

Capital costs for the main components of each system are presented in Table 1. The dechlorination unit costs were provided by Wallace and Tierman Canada Inc. The maximum treatment capacity of these systems are:

- 500 kg/d of residual chlorine with the sodium metabisulphite system.
- 220 kg/d of residual chlorine with the sulphur dioxide system.

The loading of residual chlorine expected in the Ontario Inorganic Chemical Sector effluents ranges from 6.0 kg/d to 0.012 kg/d[1].

The costs of the dechlorination units would not be reduced significantly for lower flows, since the major components of the dechlorination units are the analytical and control equipment costs.

The total estimated capital cost for the solution system is $162,900 and for the gas system is $181,000.

8.0 OPERATING COSTS

Operating costs include $500 per year for reagent for the analyzer and chemical solution or gas. Labour required to replace solution or gas cylinders, and perform routine inspection and system maintenance is estimated at 100 h per year or $2,000. Power requirements would be minimal.

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[1] This range is based on a maximum concentration of 1 mg/L of residual chlorine and a high flow of 6030 m^3/d (from Albright & Wilson, Americas) and a low flow of 12 m^3/d (from Linde (Division of Union Carbide Canada Ltd.), Moore Township Site). The source of the flow data is from the MISA 12 month Regulation Monitoring Data.

Table 1
Capital Costs of Installation of Dechlorination Systems[1]

Item	**System**			
	Sodium Metabisulphite Solution		**Sulphur Dioxide**	
	Items	**Cost ($)**	**Items**	**Cost ($)**
Dechlorination System[2]	• Pump speed controller • Chemical metering pump • Chemical feed lines • Pressure relief valves • Compound loop controller • Dechlorinator analyzer • Storage container	28,000	• Chemical feed lines • Sulfonator • Compound loop controller • Dechlorination analyzer • Tank switch valve	36,000
			• Gas cylinder deposit	2,000
	• Wastewater flowmeter	15,000	• Wastewater flowmeter	15,000
Housing and Safety Equipment	• Structure • Gas detector/alarm system • Breathing apparatus • Eye was/safety shower • Heating/air conditioning	41,500	• Structure • Gas detector/alarm system • Breathing apparatus • Eye wash/safety shower • Heating/air conditioning	41,500
Equipment Total	84,500		94,500	
Installation (@ 35%)	29,600		33,100	
Estimating Contingency (@30%)	25,400		28,400	
Engineering (@ 15%)	12,700		14,200	
Subtotal	152,200		170,200	
GST (@ 7%)	10,700		11,900	
Total	**162,900**		**181,100**	

Notes:

1. ENR CCI 6343.
2. Dechlorination unit costs were provided by Wallace & Tiernan Canada Inc.

Chemical costs ($1991), based on 1 mg/L of free chloride residual in effluents before treatment are:

• Sodium metabisulphite	-	$0.004/m^3 of effluent
• Sulphur dioxide	-	$0.001/m^3 of effluent

The range of the estimated chemical costs based on the treatment of the maximum and minimum flows from facilities in the Ontario Inorganic Chemical Sector that may consider dechlorination treatment are presented in Table 2. The concentration of chlorine was assumed to be 1.0 mg/L in these estimates.

Table 2
Chemical Costs Based on Average Flow

	Facility	
	Albright & Wilson Americas	**Linde-Union Carbide Moore Township Plant**
Flow [1](m^3/d)	6,030 m^3/d	12 m^3/d
Sodium Metabisulphite Solution[2]	$25.00/d	$0.05/d
Sulphur Dioxide[3]	$6.45/d	$0.01/d

Notes:

1. Flow based on MISA Regulation Monitoring Data
2. Based on costs provided by Dearborn Chemical Company Limited, August 1991 45% active, expressed as sodium sulphite.
3. Based on costs provided by Stanchem, September 1991.

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APPENDIX

Figures

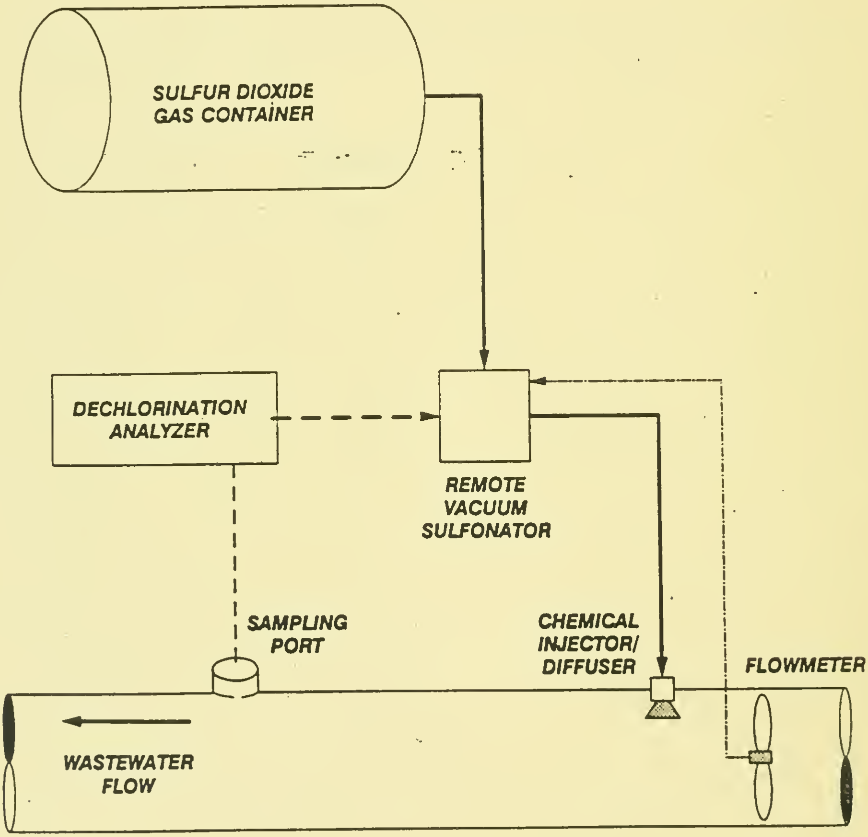

Figure A-2
SCHEMATIC OF
SULFUR DIOXIDE DISPENSING SYSTEM

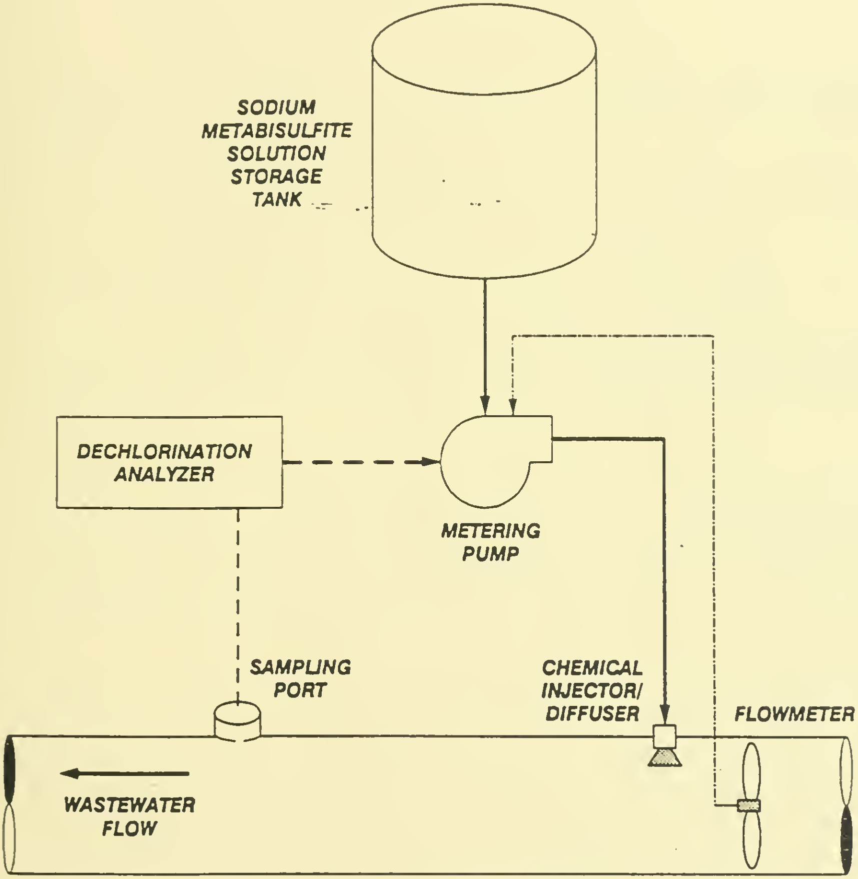

Figure A-1
SCHEMATIC OF
SODIUM METABISULFITE DISPENSING SYSTEM

TECHNOLOGY REPORT
BRINE CONCENTRATOR SYSTEMS

1.0 DESCRIPTION

Evaporative technologies used for removal of total dissolved solids from water and wastewater is referred to as brine concentration. Two types of brine concentration systems are commonly used, including:

- Multi-effect evaporative concentrators.
- Vapour compression evaporative concentrators.

Both of these types of systems are depicted in Figure A1 in the Appendix.

Both of these technologies essentially involve the evaporation of the wastewater stream to produce a high purity, high volume stream for recycle or discharge and a smaller volume, highly concentration residue stream for drying and/or appropriate disposal or re-sale.

In a multi-effect evaporator, two or more evaporation stages are present. Each stage consists of a closed tank traversed by steam. Steam produced in one stage is condensed in the heating coils of the subsequent stage which is operated at lower pressure. While single effect units produce more water per unit of evaporator tube surface and have lower capital costs (Ref. 1), multi-effect units use much less steam per volume of wastewater evaporated (Ref. 2).

Vapour compression evaporators consist of a heater, boiling chamber, vapour compressor and a heat exchanger. Pre-heated water is boiled in the chamber. Steam evolved is passed through the compressor where its pressure is raised slightly. Upon returning to the chamber, the steam condenses, giving up heat to evaporate incoming water. Condensate leaving the system passes through the heat exchanger to heat incoming wastewater. The major energy requirement for these systems is the operation of the compressor and therefore, these systems are preferred where electricity is less expensive than steam. Where excess steam is available, multi-effect evaporators are favoured.

2.0 GENERAL APPLICATION

Brine concentration is used for treating industrial wastewaters for removal of high levels of non precipitable dissolved solids, generally in excess of 50,000 mg/L. In addition, this technology may follow other TDS removal processes, such as reverse osmosis, for further concentration of the reject stream.

Brine concentration is a well established process used in the electric power generation industry for treating cooling tower and boiler blowdown, ash system reject water and water treatment residual streams (Ref. 1). In addition, this technology has been applied to desalination of saline waters from mining operations (Ref. 3). Other industrial applications include petroleum refinery effluent and oil schale production wastewater (Ref. 4).

3.0 ONTARIO APPLICATIONS

Brine concentration was considered for Ontario Inorganic Chemical Sector Industries with excessive effluent dissolved salt concentrations, including streams at General Chemical Canada Ltd. and ICI Forest Products in Cornwall.

4.0 DESIGN INFORMATION

Design requirements for brine concentration systems are dependent on a number of factors including:

- The concentration and nature of TDS in the wastewater.
- The flow rate.
- The availability and cost of steam.

For the purposes of costing brine concentrators for the two plants in the Ontario Inorganic Chemical Sector, a supplier of these systems was contacted. Preliminary system requirements specified by the supplier are presented in Table 1.

Table 1
Brine Concentrator System Requirements for Ontario Inorganic Chemical Sector Plants[1]

Plant	MISA Control Point	Description	System Description
ICI Forest Products, Cornwall	PR0400	• Primarily sodium chloride salts, at a strength of 2% Cl^-. • Flow rate of 200 m^3/d.	Falling film vapour compression preconcentrator followed by a forced circulation crystallizer.
General Chemical Canada Ltd.	CO0100	• Primarily calcium chloride salts, at a strength of 5% Cl^- • Flow rate of 15,000 m^3/d.	Multiple-effect, falling film evaporator, utilizing 2,100 kg/h of steam.

Notes:

1. Ref. 5.

5.0 PERFORMANCE

Brine concentration technologies produce an effluent distillate containing less than 10 mg/L of TDS. This high quality water is available for reuse in the plant, even in processes with stringent water quality requirements such as boilers and cooling towers, without further treatment.

Volatile pollutants that would remain in the water vapour phase, would not be removed in the system and would be present in concentrator effluents.

Generally the recovery efficiency in brine concentration systems is very high (>95 percent). However, recovery efficiency decreases as the initial TDS increases. Table 2 presents preliminary recovery efficiencies for General Chemical and ICI streams.

Table 2
Estimated Recovery Efficiency of Brine Concentrator Systems

Plant	MISA Control Point	Recovery Efficiency[1]	Residue Concentration[1]
ICI Forest Products	PR0400	92%	• Solid with less than 5% moisture
General Chemical Canada Ltd.	CO0100	86%	• 23% $CaCl_2$ • 28% NaCl

Notes:

1. Calculated from information provided by Ref. 5.

6.0 CAPITAL COSTS

Budget capital cost estimates provided by the equipment supplier are presented in Table 3.

7.0 OPERATING COSTS

Operating costs were estimated for each system being considered, based on electricity steam and labour requirements presented in Ref. 2. These costs are summarized in Table 4.

Table 3
Estimated Capital costs for Brine Concentrator Systems

Plant	MISA Control Point	System	Estimated Capital Cost[1,2]
ICI Forest Products	PR0400	Falling film vapour compression preconcentrator followed by a forced circulation crystallizer.	$2,500,000
General Chemical Canada Ltd.	CO0100	Six-effect falling film evaporator	$27,000,000

Notes:

1. Calculated from information provided by Ref. 5. Includes 15% engineering, 35% installation, 30% contingency and 7% G.S.T.
2. ENR CCI 6343.

Table 4
Estimated Annual Operating Costs for Brine Concentator Systems

Plant	Items Covered	Estimated Annual Operating Cost[1]
ICI Forest Products	• Energy • Labour • Waste disposal	$900,000
General Chemical Canada Ltd.	• Steam • Energy • Labour • Waste disposal costs excluded	$2,600,000

Notes:

1. Ref. 2.

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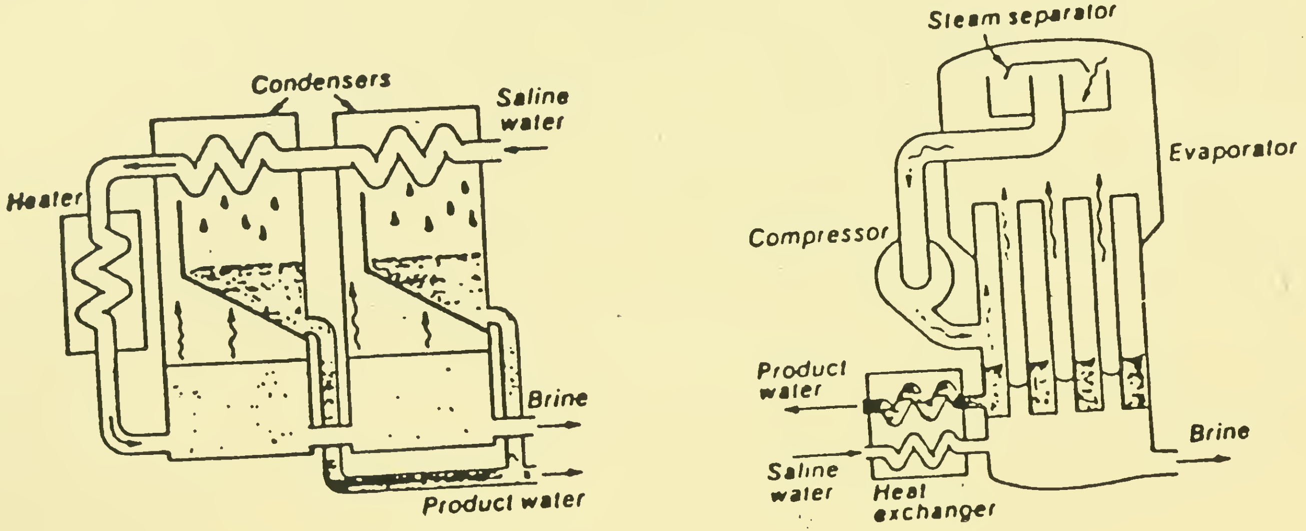
APPENDIX A

Figure



(a)
Multi–Effect
Evaporative Concentrator

(b)
Vapour Compression
Evaporative Concentrator

Figure A1

TYPICAL EVAPORATIVE BRINE CONCENTRATORS

(Ref. 1)

Section 5

PLANT SPECIFIC TECHNOLOGIES AND IN-PLANT CHANGES

PLANT SPECIFIC TECHNOLOGY REPORT PROCESS OPTIMIZATION OF SULPHIDE PRECIPITATION FOR MERCURY REMOVAL FROM WASTEWATER GENERATED IN THE CHLOR-ALKALI PROCESS

1.0 INTRODUCTION

In the United States, the Environmental Protection Agency (EPA) published (June 29, 1982) BAT discharge limits for mercury discharges from mercury cell chlor-alkali manufacturing. These limits allow the discharge of a 24-hour maximum of 0.00023 kg of mercury per tonne of chlorine produced, and a 30-day average discharge of mercury of 0.00010 kg per tonne. This limit was based on the levels the EPA determined could be achieved by using a sulphide precipitation process, with pressure filtration, on a typical cell room wastewater stream. The mercury concentration values on which these loadings were based were 0.11 mg/l for the maximum and 0.048 mg/l for the monthly average.

In the United States there are currently about 17 operating mercury cell chlor-alkali plants according to the Chlorine Institute. Sixteen (16) of these plants use sulphide precipitation to achieve BAT limits while one plant uses a hydrazine reduction process to remove mercury in the metal form. The mercury permit limits identified in the previous section have been applied to the industry in the United States as witnessed by the mercury permit limits for specific facilities detailed in Table 1.

Although the details of product capacity on which the load limits are based are not available, a clear pattern of limits that are compatible with the U.S. EPA BAT limits can be seen. The fact that so many facilities are successfully meeting these limits suggests that when operated optimally, this process is capable of achieving such limits.

The ICI Cornwall plant, in the Ontario Inorganic Chemical Sector, has in place a sulphide precipitation process with a polishing activated carbon process which would appear to meet or exceed BAT technology. In practice, the 12 months of data from the MISA Monitoring Regulation period shows that effluent limits defined by the U.S. EPA as achievable with BAT have not been met on a consistent basis at ICI (Cornwall).

Since others have succeeded in meeting the BAT goals with this technology, it is reasonable to expect that with some process optimization the ICI facility will also be able to match these limits using the technology already in place.

Table 1
ummary of Mercury Permit Limits U.S. Chlor-Alkali Facilities Using Mercury Cell Process[1]

Company Plant Location	Permit No.	Allowable Loading		Comments
		Total Hg 30-Day Avg. (kg/d)	Total Hg 24-Hr Max. (kg/d)	
B.F. Goodrich Corp. Calvert City, KY	KY0003484	0.0293	0.0674	Bioassays required.
LCP Chemicals Division of Hamlin Gp.				
- Brunswick, GA	GA0003247	0.0272	0.0626	
- Orrington, ME	ME0000639	0.0207	0.0476	
- Moundsville, WV	WV0004405	0.0227	0.0522	
Occidental Chem. Corp.				
- Mobile, AL	AL0003514	No info.	No info.	
- Muscle Shoals, AL	AL0000213	0.0363	0.0861	
- Delaware City, DE	DE0050911	40 µg/L	90 µg/L	
- Deer Park, TX	TX0007412	0.0163	0.0327	
Olin Corp.				
- Augusta, GA	GA0003719	0.0295	0.0454	20 µg/L action level for cooling water 50 µg/L for storm
- Niagara Falls, NY	NY0001635	0.0227	0.0454	
- Charleston, TN	TN0002461	0.0159	0.1225	
Pioneer Chlor-Alkali Company, St. Gabriel, LA	LA0005231	0.0454	0.104	Bioassays required.
PPG Industries, Inc.				
- Lake Charles, LA	LA0000761	0.0590	0.136	Bioassays required.
- New Martinsville, WV	WV0004359	0.0191[2]	0.0435[2]	Bioassays required.
Vulcan Chemicals				
- Port Edwards, WI	WI0003565	0.0181	0.0408	

Notes:

1. Limits shown are for process steam from mercury treatment.
2. Contested limit.

2.0 DESCRIPTION

Optimization of a mercury sulphide precipitation facility should consider a number of factors, each of which is important in achieving the desired removal efficiencies.

1. Equalization Capacity. In order to smooth out variations in the process feed, it is useful to have a mixing tank with holding capacity sufficient to equalize the flow and wastewater quality variations in advance of the first process step. The amount of equalization needed will vary depending on the operating range associated with the process at a specific facility.

2. Free Chlorine. Free chlorine should be removed from the process stream before the sodium hydrosulphide (NaSH) is added. This is commonly achieved by treating with sodium sulphite or by passing the stream through an activated carbon bed adsorber.

3. Operating pH. The pH should be reduced into the range of 6-9 before the NaSH is added. This is an important factor because at high pH levels, it is possible to form polysulphides which are much more soluble than HgS.

4. Sodium Sulphide Dosages. The dosage of sodium sulphide (Na_2S) is reasonably critical. If insufficient Na_2S is added, then not all the mercury ions will be precipitated. If too much is added, higher sulphides with greater solubility will be produced. The use of continuous oxidation/reduction probes would allow the development of a correlation to Na_2S in the wastewater leaving the Na_2S reactor in order to remain in the correct range. A sulphide level of 1.5 to 3 mg/L is an a good initial operating range. The Na_2S addition adjustments can be made automatically using the red/ox output once sufficient experience is developed.

5. Solids Removal. The removal of the fine precipitated mercuric sulphide (HgS) is usually achieved utilizing some form of pressure filtration. Bayonet leaf pressure filters are common but the use of large plate and frame filters with very high active filter areas is also successful. A number of precoating practices have been encountered including use of diatomaceous earth, cellulose, and even powdered activated carbon. Some operations continuously blend filter aid with the process liquid coming from the Na_2S reactor, while others do not. A possible variation that may have merit, would be to add the filter aid to the reactor in an effort to form larger particles more readily separated by filtration. Recycle of the already separated mercuric sulphide solids can also be used to enhance particulate growth.

6. Continuous Mercury Monitoring of Final Product Stream. At one facility, in Quebec, a continuous mercury monitor using the DuPont 400 detector systems has been developed. This equipment takes a discrete sample of the final product water about once every four minutes and performs an analysis for mercury. It is paired with another analyzer so that a new piece of data is produced every two minutes. The analyzers have been hooked up to a system of electronic valves which can automatically route the discharge water back to the equalization tank at the head of the process if effluent mercury levels exceed 50 μg/L.

7. Presence of Brine. The solubility of mercuric sulphide is very much higher in brine than in water. The treatment process must be structured to avoid any brine streams entering the treatment process stream until the mercuric sulphide has been removed by filtration.

The ICI treatment process should be critically reviewed with regard to the preceding factors and a series of experiments designed to optimize the processes should be developed based on that critical review. It seems reasonable to expect that with considerable effort and with perhaps some capital requirements, the existing process can be brought up to U.S. BAT levels.

3.0 PERFORMANCE

Based on the 12 months of data provided by the MISA Monitoring Regulation at ICI, the estimated performance that could be achieved through optimizing the system to meet U.S. BAT limits was calculated and is presented in Table 4.

An overall loading reduction of 0.044 kg/d is estimated.

Table 4
Estimated Average Performance of System Optimization at ICI (Cornwall)

Parameter	Current Average Loading (kg/d)[1]	Projected Average Loading (kg/d)[2]	Loading Reduction
Mercury	0.057 kg/d	0.013 kg/d	0.044 kg/d

Notes:

1. Mean effluent loading during 12 months of monitoring at ICI final effluent.
2. Calculated from nameplate capacity of ICI and EPA monthly average loading limit.

4.0 COSTS

Costs for optimization of the existing process at ICI cannot be determined until a complete system assessment and testing has been completed, and additional capital and operating requirements determined.

PLANT SPECIFIC TECHNOLOGY REPORT
SURFACE CONDENSER FOR AMMONIA STEAM CONDENSATION IN THE NITROGEN FERTILIZER INDUSTRY

1.0 INTRODUCTION

Currently, steam generated in the ammonium nitrate solution concentrating unit (evaporator) at ICI Nitrogen Products, Lambton Works facility is removed using a barometric condenser. Consequently, the ammonia-rich barometric condensate is included in the wastewater discharged directly from the plant. ICI Nitrogen Products is considering replacing the barometric condenser with a surface condenser operated under a vacuum (i.e. 34 to 41 kPa). The surface condenser will produce a concentrated condensate without the dilution with contact cooling water. The intention is to recycle the resulting condensate for use in liquid nitrogen fertilizer products.

Replacing the barometric condenser with a surface condenser will improve operations as follows:

- Reduce the loading of ammonia to the surface waters.
- Reduce the occurrence of spills due to the build-up of calcium salts in the barometric condenser. Occasionally calcium salt debris has fallen into the barometric leg, resulting in a back-up in the system, and a spill. ICI has initiated a program to acid wash the barometric condenser 2 to 3 times each year, depending upon the need. The replacement of the barometric condenser may reduce the occurrence of spills.
- Reduce the volume of contact/ process water discharged, since surface condensers use non-contact cooling water for condensing the steam.

2.0 GENERAL DESCRIPTION

ICI Nitrogen Products is considering the use of either a tube and shell or a plate-type heat exchanger. Once through cooling water will be used in the heat exchanger since the cooling tower does not have the capacity to provide sufficient cooling water.

A schematic of a tube and shell heat exchanger is presented in Figure A1 in the Appendix. In the tube and shell heat exchanger, non-contact cooling water is directed through the shell side, and the ammonia-rich steam is directed through the tubes.

A schematic of the plate-type heat exchanger is presented in Figure A2. The non-contact cooling water is directed through the plates and the ammonia-rich steam contacts the exterior of the plates.

In both types of heat exchangers, the non-contact cooling water can be discharged directly, and the condensate could be used in the production of liquid nitrogen fertilizer.

3.0 APPLICATION

The condensing and reuse of contaminated steam, similar in composition to the steam produced in the ammonium nitrate concentrating unit, has been successfully demonstrated at the Lambton Works facility. Steam contaminated with ammonia, nitric acid and ammonium nitrate produced in the Nitric Acid Neutralization Plant, is used to vaporize liquid ammonia. The condensed contaminated steam is then used to make prills of ammonium nitrate.

4.0 DESIGN INFORMATION

On average the heat exchanger system would condense 55 tonnes of steam each day. Sizing to account for peak flow conditions would require a 66 tonne/d unit.

Specific design information was provided by ICI Nitrogen Products for the two heat exchanger options. These are included in the Appendix. Attachment A1 is the specification sheet for the plate heat exchanger and Attachment A2 is the specification sheet for the shell and tube heat exchanger. Figure A3 is a preliminary schematic for the proposed plate heat exchanger and Figure A4 is a preliminary schematic for the proposed shell and tube heat exchanger.

The intention is to recycle the condensate as make-up water for the liquid fertilizer plant. However, the calculated average flow of 55 tonnes/d of contaminated condensate exceeds the need for make-up water. Hence, other alternatives are being examined which include:

- Increasing the strength of the ammonium nitrate liquor from the current 81 to 82 percent liquor to 87 percent liquor, by improving the performance of the ammonium nitrate reactor. This would reduce the production of contaminated steam.

- Using a falling film evaporator to remove dilution water from the ammonium nitrate liquor. The resulting clean water vapour would then be exhausted to the atmosphere.

Design Limitations

The performance of the surface condensers may be depend upon concentration of contaminants in the wastewater in that if the concentration of contaminants is sufficiently high, then corrosion may occur. However, with proper selection of the heat exchanger material, this anticipated problem may be avoided. ICI Nitrogen Products does not anticipate a problem with fouling due to the composition of the contaminated steam.

5.0 PERFORMANCE

To project the reduction in the ammonia-ammonium found in the plant effluent, the 12 month MISA Monitoring data were examined. Currently, the barometric condensate combines with an insignificant amount of wash water from the ammonium nitrate manufacturing unit, prior to the MISA Control Point PR0300. Consequently, the average flow measured at this Control Point can be assumed to equal the flow from the barometric condenser.

Based on the flow and the ammonia-ammonium concentration data collected during the 12 month MISA Monitoring period, and assuming that all of the ammonia-ammonium found at this Control Point originated from the barometric condenser, replacing the barometric condenser with a surface condenser should result in a 97 kg/d reduction in the ammonia-ammonium loading.

The amount of non-contact cooling water used by the proposed surface condensers amounts to 3,365 m^3/d. The barometric condenser condensate discharged approximately 3,590 m^3/d of contact cooling water during the MISA monitoring period. Thus water usage would not be reduced significantly, however, the amount of contact cooling water would be significantly reduced.

6.0 OPERATING REQUIREMENTS

Hydroelectric power for pump operation and cooling water will be required to operate the condensing system.

7.0 CAPITAL COSTS

The capital cost of the condenser (either one) was estimated to be $42,000 (ENR CCI 6343) by ICI Nitrogen Products.

A total cost provided by ICI Nitrogen Products was estimated to be $257,000 (ENR CCI 6343) which includes:

- Condenser with associated piping and instrumentation
- Seal tank with attached condensate transfer pump
- Installation
- Insulation

- Engineering
- GST

8.0 OPERATING COSTS

The annual projected cost of the operation of this unit as provided by ICI Nitrogen Products was $30,000 and includes the cost of utilities (hydro and cooling water) and maintenance. These operating costs do not include any savings incurred by ICI Nitrogen Products by the decrease in water use or potentially power reduction resulting from the replacement of the barometric condenser.

9.0 REFERENCES

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APPENDIX

Figures and Attachments

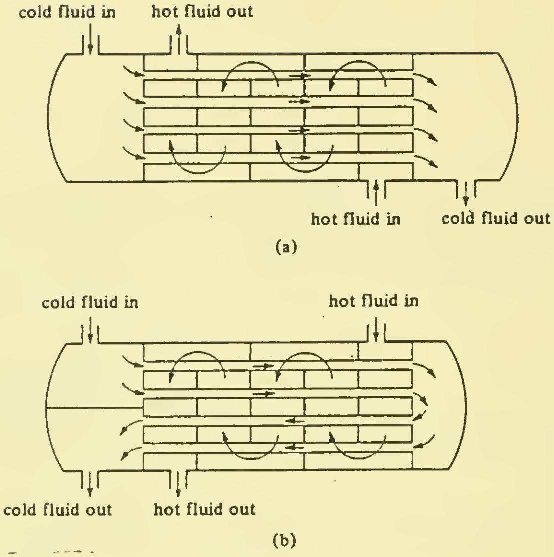


Figure A 1

SHELL & TUBE HEAT EXCHANGERS

(a) Shell Pass & Tube Pass, 1-1 Exchanger

(b) 1 Shell Pass & 2 Tube Passes, 1-2 Exchanger

Source: Geankoplis

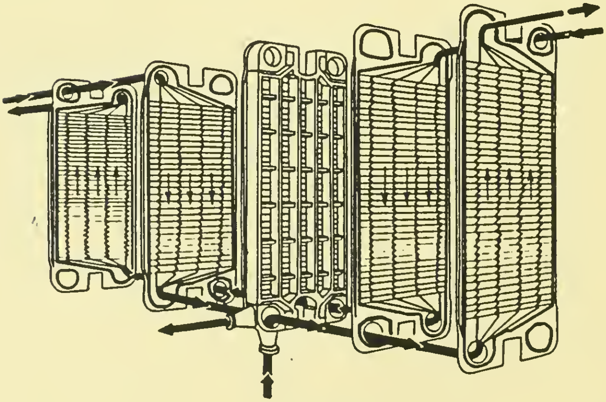


Figure A2

PLATE- (& FRAME) TYPE EXCHANGER

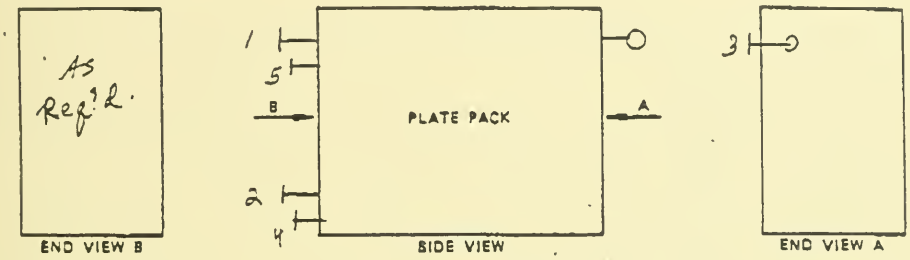
Source: Perry

CIL Manufacturing and Technology, Corporate Engineering

SPECIFICATION SHEET
PLATE HEAT EXCHANGER

SPEC. NO.	LW 90-007		
ISSUE	1	PAGE 3	OF 3
BY	T. E		
DATE	July 4, 1990		

SKETCH



Suggested Branch Connections – may be altered to suit design requirements. Condenser "boot" requirement waived (will be external).

Figure A3
SPECIFICATION SHEET,
PLATE HEAT EXCHANGER

Source: ICI Nitrogen Products

Note: All Flanges to be 150# R.F.

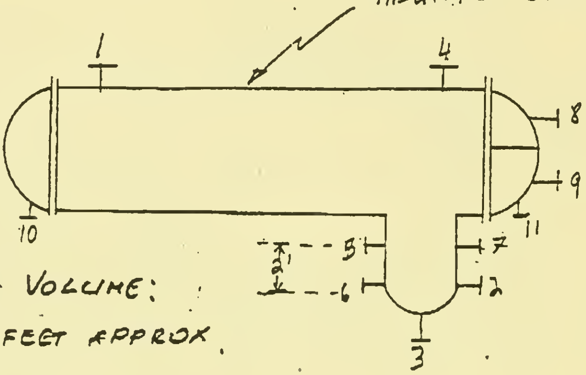
BRANCH CONNECTIONS (PROCESS REQUIREMENTS ONLY)

NO.	NB (ins)	DESCRIPTION	NO.	NB (ins)	DESCRIPTION
1	6"	Hot Gas Inlet			
2	6"	Condensate Outlet			
3	1/2"	Gas Vent to ejector			
4	4"	Cooling Water Inlet			
5	4"	Cooling Water Outlet			

SHELL & TUBE HEAT EXCHANGER

DATE Apr 12, 1990

SKETCH



insulate shell incl. Boot

Boot Volume:
5 cu feet approx

Figure A4

SPECIFICATION SHEET,

SHELL & TUBE HEAT EXCHANGER

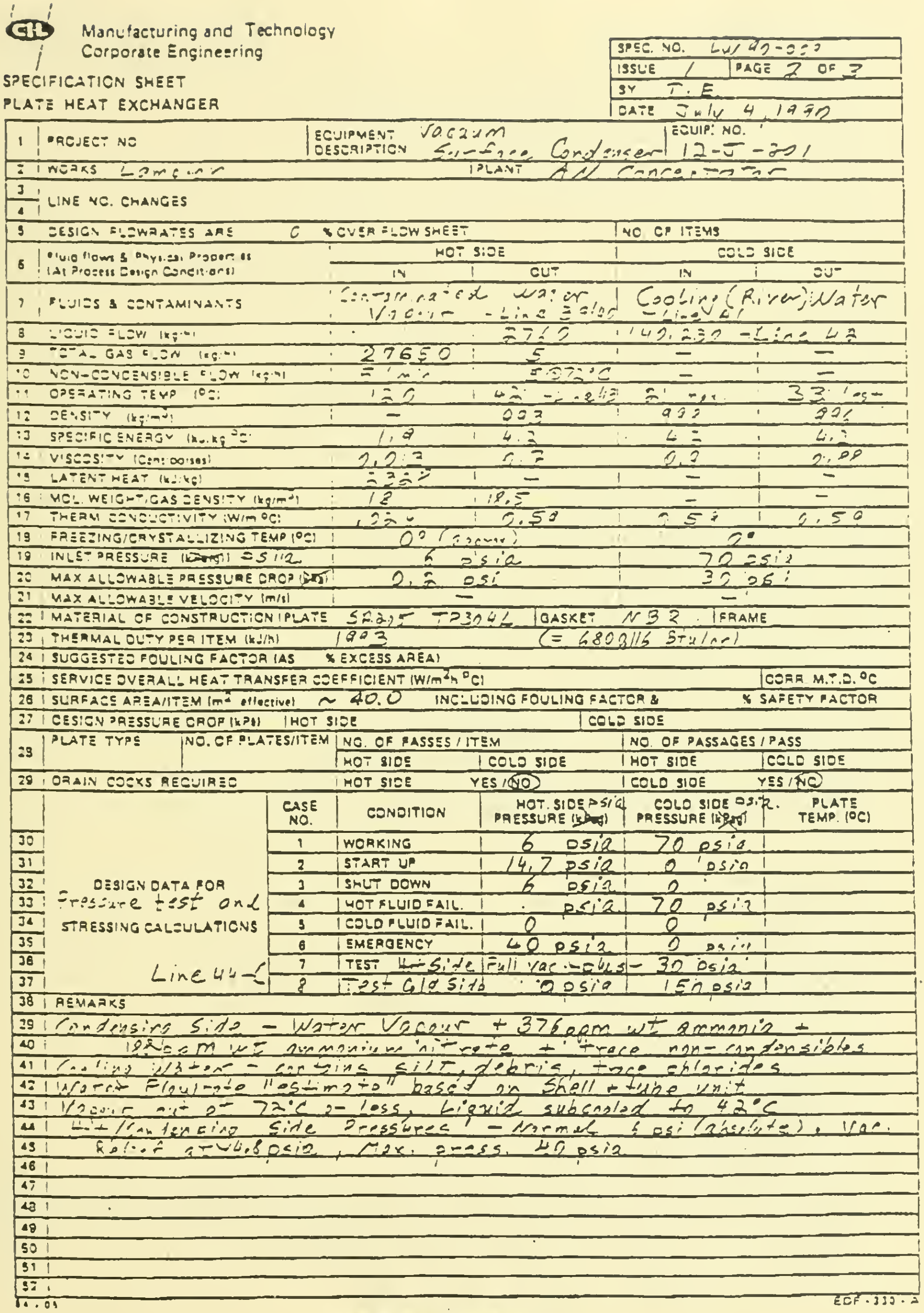
Source: ICI Nitrogen Products

BRANCH CONNECTIONS (PROCESS REQUIREMENTS ONLY)

NO.	NB (ins)	DESCRIPTION	NO.	NB (ins)	DESCRIPTION
1.	6"	Process Inlet.	8	4"	C. Water Inlet
2	2"	Condensate Outlet	9	4"	C. Water Outlet
3.	1"	Drain.	10 + 11	1"	Drain
4	1½"	Vent – to ejector.			
5+6	3/4"	Level transmitter conn.			
7	1"	Nozzle + Thermowell			

82/04

EDF-331



Manufacturing and Technology
Corporate Engineering

SPECIFICATION SHEET
PLATE HEAT EXCHANGER

SPEC. NO. Lu/ 90-002	
ISSUE 1	PAGE 2 OF 3
BY T. E.	
DATE July 4, 1990	

1	PROJECT NO	EQUIPMENT DESCRIPTION Vacuum Surface Condenser		EQUIP. NO. 12-J-201	
2	WORKS [illegible]		PLANT AN Concentrator		
3 4	LINE NO. CHANGES				
5	DESIGN FLOWRATES ARE 0 % OVER FLOW SHEET			NO. OF ITEMS	
6	Fluid flows & Physical Properties (At Process Design Conditions)	HOT SIDE IN	HOT SIDE OUT	COLD SIDE IN	COLD SIDE OUT
7	FLUIDS & CONTAMINANTS	Contaminated water Vapour - Line 3[illegible]		Cooling (River) Water - Line 41	
8	LIQUID FLOW (kg/h)		2760	140,230 - Line 42	
9	TOTAL GAS FLOW (kg/h)	27650	5	—	—
10	NON-CONDENSIBLE FLOW (kg/h)	5 / min	@ 72°C	—	—
11	OPERATING TEMP (°C)	120	42 - Line 43	21 avg.	33 avg.
12	DENSITY (kg/m³)	—	993	999	996
13	SPECIFIC ENERGY (kJ/kg °C)	1.9	4.2	4.2	4.2
14	VISCOSITY (Centipoises)	0.013	0.7	0.9	0.88
15	LATENT HEAT (kJ/kg)	2332	—	—	—
16	MOL. WEIGHT/GAS DENSITY (kg/m³)	18	18.5	—	—
17	THERM. CONDUCTIVITY (W/m °C)	.024	0.58	0.57	0.59
18	FREEZING/CRYSTALLIZING TEMP (°C)	0° (approx)		0°	
19	INLET PRESSURE (~~kPag~~) psia	6 psia		70 psia	
20	MAX ALLOWABLE PRESSURE DROP (~~kPa~~)	0.2 psi		30 psi	
21	MAX ALLOWABLE VELOCITY (m/s)	—		—	
22	MATERIAL OF CONSTRUCTION PLATE	SA240 TP304L	GASKET NBR		FRAME
23	THERMAL DUTY PER ITEM (kJ/h)	1893	(= 6808116 Btu/hr)		
24	SUGGESTED FOULING FACTOR (AS % EXCESS AREA)				
25	SERVICE OVERALL HEAT TRANSFER COEFFICIENT (W/m² h °C)				CORR. M.T.D. °C
26	SURFACE AREA/ITEM (m² effective) ~ 40.0	INCLUDING FOULING FACTOR &			% SAFETY FACTOR
27	DESIGN PRESSURE DROP (kPa)	HOT SIDE		COLD SIDE	
28	PLATE TYPE / NO. OF PLATES/ITEM	NO. OF PASSES / ITEM HOT SIDE	COLD SIDE	NO. OF PASSAGES / PASS HOT SIDE	COLD SIDE
29	DRAIN COCKS REQUIRED	HOT SIDE YES / [✓ NO]		COLD SIDE YES / [✓ NO]	

		CASE NO.	CONDITION	HOT. SIDE PRESSURE (~~kPag~~) psia	COLD SIDE PRESSURE (~~kPag~~) psia.	PLATE TEMP. (°C)
30	DESIGN DATA FOR Pressure test and STRESSING CALCULATIONS Line 44	1	WORKING	6 psia	70 psia	
31		2	START UP	14.7 psia	0 psia	
32		3	SHUT DOWN	6 psia	0	
33		4	HOT FLUID FAIL.	psia	70 psia	
34		5	COLD FLUID FAIL.	0	0	
35		6	EMERGENCY	40 psia	0 psia	
36		7	TEST ~~Hot~~ Side	Full vac - abs	- 30 psia	
37		8	Test Cld Side	0 psia	150 psia	

38 REMARKS
39 Condensing Side - Water Vapour + 376 ppm wt ammonia +
40 192 ppm wt ammonium nitrate + trace non-condensibles
41 Cooling Water - contains silt, debris, trace chlorides
42 Water Flowrate "estimate" based on Shell + tube unit
43 Vapour out at 72°C [illegible] less, Liquid subcooled to 42°C
44 ~~Hot~~/Condensing Side Pressures - Normal 6 psi (absolute), Vac.
45 Relief at ~4.8 psia, Max. press. 40 psia
46
47
48
49
50
51
52

84-05 EDF-330-A

Attachment A1

SPECIFICATION SHEET, PLATE HEAT EXCHANGER

Source: ICI Nitrogen Products

SPECIFICATION SHEET
SHELL & TUBE HEAT EXCHANGER

ISSUE → 1 | PAGE 1 OF 2
BY T.F.
DATE Apr 12, 1990

1	PROJECT NO	SERVICE Condensing		EQUIP. NO 12-5-201
2	WORKS Lambton		PLANT AN Concentrator	
3	DUTY 1683 (kW)	EXCHANGER TYPE: HORIZ VERT		

		SHELL SIDE		TUBE SIDE	
4	FLUID Note (1)	Contaminated Water Vapour		Cooling (River) Water	
5	TOTAL FLOW (kg/h)	2765		(min.) 140230 ③	
6		Inlet	Outlet	Inlet	Outlet
7	LIQUID (kg/h)		2760	140230	140230
8	Density (kg/m³)	@ °C	993 @ 42 °C	998 @ 21 °C	995 @ 33 °C
9	Thermal Cond (W/m °C)	@ °C	0.59 @ 42 °C	0.59 @ 21 °C	0.59 @ 33 °C
10	Specific Energy (kJ/kg °C)	@ °C	4.2 @ 42 °C	4.2 @ 21 °C	4.2 @ 33 °C
11	Viscosity (Centipoises)	@ °C	0.7 @ 42 °C	0.9 @ 21 °C	0.8 @ 33 °C
12					
13	See note ①	Water vapour	Vapour + Air		
14	VAPOUR (kg/h)	2765	5		
15	Molecular Weight	18	18.5		
16	Thermal Cond (W/m °C)	.024 @ 120 °C	.024 @ 72 °C	@ °C	@ °C
17	Specific Energy (kJ/kg °C)	1.8 @ 120 °C	1.9 @ 72 °C	@ °C	@ °C
18	Viscosity (Centipoises)	.013 @ 120 °C	.011 @ 72 °C	@ °C	@ °C
19	Latent heat kJ/kg	2222	–	–	–
20	ADDITIONAL DATA ON SHEET NO				
21	OPERATING TEMPERATURES (°C)	120	72	21°	33
22	Press's (~~kPa~~(g)) psi (absolute)	5.0 psia	5.0	70 psia	65 psia
23	Velocities (m/s)				
24	Pressure Drop (Note A) (~~kPa~~)	Allow 0.3 psi	Calc	Allow 5 psi	Calc
25	DESIGN TEMPERATURES (°C)	150		40	
26	Pressure (~~kPa~~(g)) psia	Min Full Vacuum +15 psi	Test 40	Min. 90 psia	Test
27	Foul. Resist (m² °C/W)	Min 0.001	Calc.	Min.	Calc.
28	Min Corrosion Allowance (mm)				
29	NUMBER OF PASSES PER SHELL	ONE		1 or 2	
30	FLOW ARRANGEMENT	/ Par. Banks of	/ Exch. In Series	/ Par. Banks of	/ Exch. In Series

31	Tot Area (Note B) 270 FT² ~~m²~~	Shell No x I.D. x mm	Cross Baffles, Type
32	Ltmd	Tubes, No Per Shell	Number x Spacing x mm
33	Corrected Mtd	O.D. x Length mm x mm	Segment Cut
34	Transfer Rate, Clean	Gauge, bwg Ave., Min Wall	Impingement Baffle (Yes) (No)
35	Service	Tube Pitch mm △ □ ◇	Weights Each Bundle kg
36	Code Requirements ASME, TEMA	Removable Tube Bundle (Yes) (No)	Bundle And Shell kg
37	Code Stamp (Note C) (Yes) (No)	Floating Head Split Ring Pull Thru U-Tube	Full Of Water kg

		NOZZLES (Note C)	SHELL SIDE			TUBE SIDE		
38	MATERIALS (Mark Stress Relieved – S.R., Radiographed – X R.)		No	Size	Rating & Facing	No	Size	Rating & Facing
39	Tubes 310 SS	Inlet	1	6"		8	6"	
40	Tube Sheets	Outlet	2	2"		9	4"	
41	Baffles	Drain	3	1"		10	1"	
42	Tube Supports	Vent	4	1½"		11	1"	
43	Tie Rods & Spacers	[illegible]	5	3/4"				
44	Long Baffle	[illegible]	6	3/4"				
45	Shell	Thwell	7	1"				
46	Shell Cover / Flange							
47	Channel							
48	Channel Cover / Flange							
49	Floating Head Cover							
50	Channel Flanges							
51	Channel Noz. Flanges							
52	Shell Flanges							
53	Shell Noz. Flanges							

54 REMARKS ③ C.W. flow minimum estimate, Actual flow may be higher
55 (1) Shell side Fluid: water vapour, trace air, Ammonium nitrate (188 ppm wt.),
56 ammonia (376 ppm wt.) – trace noncondensibles.
57 (2) Cooling Water contains silt, debris, chlorides

NOTE A. For Condensers and Thermosyphon Reboilers Pressure Drop Stated Shall Include Static Head Between Centerlines of Inlet and Outlet Flanges.

C. Rate Per ANSI B16.5

B: Outside Tube Area Excluding Area In Tube Sheets.

Attachment A2
SPECIFICATION SHEET, SHELL & TUBE HEAT EXCHANGER

Source: ICI Nitrogen Products

TECHNOLOGY REPORT
AMMONIA REMOVAL BY STEAM STRIPPING FOR NITROCHEM INC.

1.0 DESCRIPTION

Steam stripping is an effective method of removing volatile contaminants such as ammonia from wastewater. Ammonia removal by steam stripping involves introducing steam at the bottom of either a packed column, or a bubble or sieve plate tower. Steam flows counter current to an ammonia-rich wastewater stream. Because the ammonia is volatile, it becomes entrained in the steam and is removed from the wastewater. The ammonia-rich steam is collected, and may be directed to a spray absorber where it may be reacted with dilute sulphuric acid to produce a solution of ammonium sulphate. The ammonium sulphate may then be recovered by evaporation, crystallization, centrifugation and drying. Alternatively, the ammonia rich steam may be condensed, and the ammonia-rich condensate may be used in the production of liquid fertilizers. This second option has been proposed for the ammonia-rich wastewater produced at Nitrochem Inc. The fate of the gaseous ammonia produced in the condensing of the ammonia-rich stream has not been identified.

Factors which effect the removal efficiency of the steam stripper include:

- Structural configuration of the steam stripper including the height, packing size and type, or tray design. The packing or trays should be designed to provide sufficient droplet detainment space.
- Hydraulic loading rate.
- Rate of steam injection.
- pH of the influent. A pH greater than 11 maximizes ammonia removal but will also introduce a need to neutralize the stripper effluent.
- Temperature of the column. A temperature of greater than 94 °C will maximize the removal of ammonia from the wastewater.
- Location of wastewater introduction to optimize reflux action.

Appendix Figure A1 presents a simplified schematic of a stripper/condensing system.

2.0 GLOBAL APPLICATIONS

Steam stripping has been used to treat ammonia-rich effluents from coking, ferro-alloy production, coal gasification, petroleum refining, agroindustries, fertilizer manufacturing, rayon production and incandescent bulb production (Ref. 3).

Steam stripping is most effective on concentrated streams, where the concentration of ammonia-ammonium exceeds 500 mg/L. Generally, biological nitrification is the most effective method of ammonia removal for intermediate to low levels of ammonia (i.e. less than 500 mg/L of ammonia) (Ref. 1).

3.0 ONTARIO APPLICATION

The applicable streams in the Ontario Inorganic Chemical Sector, the average flow of the streams and the estimated ammonia-ammonium concentrations are presented in Table 1. Nitrochem Inc. has applied for a Certificate of Approval for a steam stripper and steam condenser. The design specifications and costs for both units is discussed in this report.

Table 1
Applicable Streams in the Ontario Inorganic Chemical Sector

Company	Stream	Mean Ammonia-Ammonium Concentration (mg/L)[1]	Flow (m^3/d)
Nitrochem Inc., Maitland	Hydrogen Plant Texaco™ Generator Blowdown	700	91
	Hydrogen Plant Process Condensate	400	72

Notes:

1. Estimates provided by Nitrochem Inc.

4.0 DESIGN INFORMATION

Typical design criteria for a steam stripping unit are presented in Table 2 (Ref. 3).

The design specifications of the steam stripper proposed by Nitrochem Inc. are presented in Table 3. The proposed steam stripper is a combination stripper with bubble cap trays with a 1.8 m section packed with 5 cm Raschig rings. No schematic diagram for the proposed steam stripper unit was provided by Nitrochem Inc. A combined stream consisting of Hydrogen Plant Texaco™ Generator blowdown and process condensate will be treated with spent caustic, and sodium carbonate, to a pH within the range of 8 to 9, prior to steam stripping.

Table 2
Typical Steam Stripper Design Criteria[1]

Design Parameter	Units	Value/range
Column height	m	6 to 18
Column diameter	m	0.9 to 1.8
Steam requirement	kg/L	0.07 to 0.24
Typical wastewater flow	L/min	760

Source:

1. Ref. 3, p. III.3.1.19-6.

Table 3
Nitrochem Inc. Steam Stripper Design Information

Design Parameter	Specification
Number of theoretical trays	7
Type of tray	Bubble tray/packed column
Height of tower	8.8 m
Diameter of tower	1.1 m
Pressure of steam	450 kPa
Temperature of steam	148 °C
Maximum flow of condensate to tower	164 m^3/d
Flow of steam	900 kg/h

Source:

1. Ref. 9.

Associated with the steam stripper is a tube and shell condenser unit used to condense the ammonia-rich steam. Design specifications of this condenser are provided in Table 4. Nitrochem intends on using the condensed ammonia solution to make fertilizer.

5.0 PERFORMANCE

Steam stripper performance data for several sources of wastewater (Ref. 1) are presented in Table 5. All sources reported ammonia removal efficiencies greater than 95 percent.

Table 4
Nitrochem Inc. Condenser Unit

Design Parameter	Specification
Type of condenser	tube and shell
Cooling method	non-contact cooling water
Estimated rate of condensate production	0.32 m^3/d
Cooling water usage	2,580 m^3/d
Design rate of heat exchange	2.32 million kJ/h
Effective surface area of condenser	0.12 m^2

Source:

1. Ref. 9.

Table 5
Performance of Steam Strippers for Ammonia Removal[1]

Wastewater Source	Influent Ammonia Nitrogen Concentration (mg/L)	Removal Efficiency (%)
Refinery sour water	1,800	98
Ion exchange column elutriant	600	98
Petrochemical waste	1,810	98
Nuclear fuel processing	1 to 3% NH_4F and 3 to 10% free NH_3	99.4
Tantalum and columbium plant waste	35,000	99
Coke plant waste	2,000 to 6,000	95 to 99

Source: Ref. 1.

Nitrochem Inc. anticipates the removal efficiency of the proposed stripper/condenser system to average 95 percent. They expect the final effluent from the stripper unit to have an ammonia-ammonium concentration no greater than 23 mg/L when the stripper is treating 155 m^3/d of contaminated condensate.

In the General Technology Report (Ref. 7), loading reductions for dissolved organic carbon (67.1 percent), and total keldjahl nitrogen (90.6 percent), as well as, ammonia-ammonium (92.7 percent) were reported. If all of the ammonia-ammonium, TKN and DOC found at MISA Control Point CO0400 were assumed to originate from the Texaco^{TM} Generator blowdown, and the hydrogen plant process condensate, then the estimated loading reduction could be predicted. These estimates are presented in Table 6.

6.0 OPERATING REQUIREMENTS

A supply of steam and cooling water is required for operation of a stripper/condenser unit. As well, the steam pressure and flows in the column must be monitored and maintained to achieve maximum efficiency.

Table 6
Estimated Loading Reductions

Parameter	Current Loading[1] (kg/L)	Estimated Removal Efficiency[2] (%)	Predicted Loading After Stream Stripping[2] (kg/L)
Ammonium-Ammonia	97.0	92.7	7.1
Dissolved Organic Carbon	19.5	67.1	6.4
Total Keldjahl Nitrogen	105.2	90.6	9.9

Notes:

1. Based on 12 month MISA Monitoring Regulation data at CO0400. All loading assumed to originate from Hydrogen Plant process water.
2. Based ICI Nitrogen Products, (Ref. 7).

7.0 CAPITAL COSTS

The costs for the proposed ammonia stripper/condenser system, provided by Nitrochem Inc. are presented in Table 7.

8.0 OPERATING COSTS

Operating costs were not provided by Nitrochem Inc.

9.0 REFERENCES

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3. Office of Research and Development. *Treatability Manual, Volume III. Technologies for Control/Removal of Pollutants.* Washington, D.C.: U.S. Environmental Protection Agency, 1981.

Table 7
Estimated Cost for Nitrochem Ammonia Stripper/ Condenser System

Item	Cost ($)
Piping, concrete, tanks, steel	195,000
New stripper	160,000
New condenser	15,000
Equipment costs	370,000
Contingency allowance	20,000
Engineering (@ 15%)	58,500
Installation (@ 35%)	129,500
Sub total	578,000
GST (assume 7%)	40,500
Total estimated cost	618,500

Notes:

1. All prices include escalation of material and labour.
2. Prices were originally developed in 1989. They have been pro-rated to 1991 values by Nitrochem, Inc.
3. Based on ENR CCI[1]6343.

4. Geankoplis, Christie J., *Transport Processes and Unit Operations.* Toronto, Ontario: Allyn and Bacon, Inc.,1978.

5. Burru, Joshua. Nitrochem Inc. telephone and telefax communication, Aug/ Sept 1991.

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7. General Technology Report, Ammonia Removal by Steam Stripping for ICI Nitrogen Products.

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[1] Engineering News Record Construction Cost Index.

APPENDIX

Figure

Figure A1
SCHEMATIC OF A TYPICAL STEAM STRIPPING PROCESS

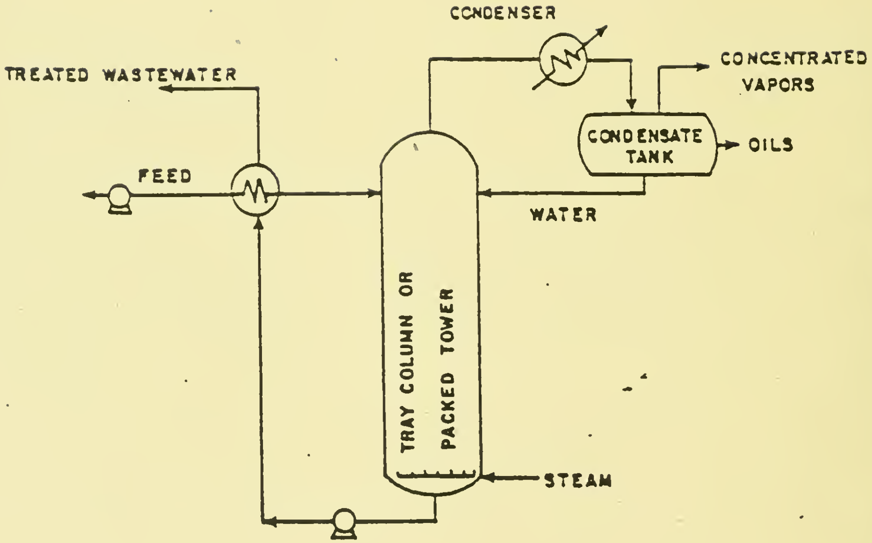

FIGURE A1
SCHEMATIC OF A TYPICAL STEAM STRIPPING PROCESS

TECHNOLOGY REPORT
AMMONIA REMOVAL BY STEAM STRIPPING FOR ICI NITROGEN PRODUCTS

1.0 INTRODUCTION

The purpose of this General Technology Report is to present a case study of a steam stripper designed to remove ammonia from wastewater at ICI Nitrogen Products. Since the ammonia steam stripper at ICI has already been installed, no further ammonia removal technology is recommended. The performance data including dissolved organic carbon, ammonia-ammonium and total keldjahl nitrogen presented in this case study, will be used to project performance of similar systems (Ref. 10).

2.0 DESCRIPTION

Steam stripping is an effective method of removing volatile contaminants such as ammonia from wastewater. Ammonia removal by steam stripping involves introducing steam at the bottom of either a packed column, or a bubble or sieve plate tower. Steam flows counter current to an ammonia-rich wastewater stream. Because the ammonia is volatile, it becomes entrained in the steam and is removed from the wastewater. The ammonia-rich steam may be collected, directed to a spray absorber, then reacted with dilute sulphuric acid to produce ammonium sulphate. The ammonium sulphate may then be recovered by evaporation, crystallization, centrifugation and drying. Alternatively, the ammonia rich steam may be condensed, and the ammonia-rich condensate may be used in the production of liquid fertilizers.

Factors which effect the removal efficiency of the steam stripper include:

- Structural configuration of the steam stripper including the height, packing size and type, or tray design. The packing or trays should be designed to provide sufficient droplet detainment space.
- Hydraulic loading rate.
- Rate of steam injection.
- pH of the influent. A pH greater than 11 maximizes ammonia removal but will also introduce a need to neutralize the stripper effluent.
- Temperature of the column. A temperature of greater than 94 °C will maximize the removal of ammonia from the wastewater.
- Location of wastewater introduction to optimize reflux action.

Appendix Figure A1 presents a simplified schematic of a stripper/condensing system.

3.0 GLOBAL APPLICATIONS

Steam stripping has been used to treat ammonia-rich effluents from coking, ferroalloy production, coal gasification, petroleum refining, agroindustries, fertilizer manufacturing, rayon production and incandescent bulb production (Ref. 3).

Steam stripping is most effective on concentrated streams, where the concentration of ammonia-ammonium exceeds 500 mg/L. Generally, biological nitrification is the most effective method of ammonia removal for intermediate to low levels of ammonia (i.e. less than 500 mg/L of ammonia) (Ref. 1).

4.0 ONTARIO APPLICATION

The applicable streams in the Ontario Inorganic Chemical Sector, the average flow of the streams and the estimated ammonia-ammonium concentrations are presented in Table 1. ICI Nitrogen Products has been granted a Certificate of Approval for the operation of a Braun steam stripper which discharges to the atmosphere. The Braun stripper was operating during the MISA Monitoring Regulation period except for the period between February 28 to April 10, 1991, when the unit was relocated.

Table 1
Applicable Streams in the Ontario Inorganic Chemical Sector

Company	Stream	Mean Ammonia-Ammonium Concentration[1] (mg/L)	Flow[1] (m^3/d)
Nitrochem Inc., Maitland	Hydrogen Plant Texaco Generator Blowdown	700	91
	Hydrogen Plant Process Condensate	400	72
ICI Nitrogen Products, Nitrogen Products Lambton Works	Process Condensate from Ammonia 2 Plant	280	326

Notes:

1. Estimates provided by each respective company.

In this report, a steam condensing system will be considered to eliminate air emissions. The design specifications and unit costs are based upon information provided by Nitrochem Inc.

5.0 DESIGN INFORMATION

Typical design criteria for a steam stripping unit are presented in Table 2 (Ref. 3).

Table 2
Typical Steam Stripper Design Criteria[1]

Design Parameter	Units	Value/range
Column height	m	6 to 18
Column diameter	m	0.9 to 1.8
Steam requirement	kg/L	0.07 to 0.24
Typical wastewater flow	L/min	760

Source:

1. Ref. 3, p. III.3.1.19-6.

The design specifications for a Braun stripper, a type of ammonia stripper proposed by ICI Nitrogen Products, are presented in Table 3. Currently ICI Nitrogen Products vents the ammonia-rich steam to the atmosphere through a stack above the tower. The "clean" condensate is discharged through the bottom of the tower to the MISA Control Point CO0800. A schematic diagram of the unit is presented in Appendix Figure A.2.

Table 3
Braun Tower Design Information

Design Parameter	Specification
Number of trays	30
Type of tray	sieve
Height of tower	26.8 m
Diameter of tower	1.2 m
Temperature in tower	140 °C
Pressure in tower	344 kPa
Maximum flow of condensate to the tower	720 m^3/d
Flow of steam	2.5 t/h
Steam exhaust rate	0.66 m^3/s (57,000 m^3/d)
Mass of tower	35 t

Source:

1. Ref. 6.

Instead of discharging the steam to the atmosphere, ICI Nitrogen Products may consider condensing the steam, and using the ammonia-rich condensate for liquid nitrogen fertilizer production. Based on the temperature, pressure and rate of steam usage, the condenser required to condense the steam to 40 °C must have the capacity to remove 6.4 million kJ/h of heat.

6.0 PERFORMANCE

General

Steam stripper performance data for several sources of wastewater (Ref. 1) are presented in Table 4. All sources reported ammonia removal efficiencies greater than 95 percent.

Table 4
Performance of Steam Strippers for Ammonia Removal

Wastewater Source	Influent Ammonia Nitrogen Concentration (mg/L)	Removal Efficiency (%)
Refinery sour water	1,800	98
Ion exchange column elutriant	600	98
Petrochemical waste	1,810	98
Nuclear fuel processing	1 to 3% NH_4F and 3 to 10% free NH_3	99.4
Tantalum and columbium plant waste	35,000	99
Coke plant waste	2,000 to 6,000	95 to 99

Source:

1. Ref. 1.

ICI Nitrogen Products

Actual performance data for the Braun stripper compiled over six operating days, are presented in Table 5.

The loading reductions anticipated for the permanent installation of the Braun in the Ammonia II unit, are presented in Table 6. Because the Braun stripper was operating during most of the MISA Monitoring Regulation period, (with the exception of the operating period from February 28 to April 10, 1991), no further improvement in the effluent from ICI Nitrogen Products will be observed.

7.0 OPERATING REQUIREMENTS

A supply of steam and cooling water is required for operation of a stripper/condenser unit. As well, steam pressure, flows, effluent pH and ammonia concentrations in the column must be monitored and to achieve maximum efficiency.

Table 5

Braun Stripper Performance Data[1]

Parameter	Units	Influent	Removal Efficiency	
			Range	Average
Condensate Flow	m^3/d	505	Not Applicable	Not Applicable
pH		9.65	Not Applicable	Not Applicable
Dissolved Organic Carbon	mg/L	60.3	55.5 - 76.5	67.1
Ammonia-Ammonium	mg/L	157	83.8 - 95.5	92.7
Total Keldjahl Nitrogen	mg/L	159.8	81.0 - 94.6	90.6

Note:

1. Data derived from composite samples taken over six days between June 6 to June 27, 1991. Data were provided by ICI Nitrogen Products.

Source: Ref. 4.

Table 6

Reported Loading Reductions

Parameter	Loading Without Use of Stripper (kg/d)	Loading with Use of Stripper (kg/d)
Dissolved Organic Carbon	30.4	10.0
Ammonia-ammonium	79.3	5.79
Total keldjahl nitrogen	80.7	7.59

Note:

1. Based on data collected between June 6 to June 27, 1991, provided by ICI Nitrogen Products.

8.0 CAPITAL COSTS

No capital cost for the Braun stripper was provided by ICI Nitrogen Products.

The cost for the installation of the condenser unit at ICI Nitrogen Products would be around $62,700. This capital cost of the condenser was determined based upon costs provided by Nitrochem Inc. The cost breakdown is presented in Table 7.

9.0 OPERATING COSTS

Operating costs were not provided by ICI Nitrogen Products. They indicated that the operating costs would be attributed to the production of steam only.

Table 7
Cost Estimation for Steam Condenser for Braun Stripper Steam

Items	Cost ($)
Condenser	32,500[1]
Installation (@ 35%)	11,400
Contingency allowance (@ 30%)	9,800
Engineering (@ 15%)	4,900
Subtotal	58,600
GST (@7%)	4,100
Total	62,700

Note:

1. Based on cost equation, and costs provided by Nitrochem (1991) (Ref. 8).
2. ENR CCI[1] 6343.

10.0 REFERENCES

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9. Office of Research and Development. *Treatability Manual, Volume IV. Cost Estimating.* Washington, D.C.: U.S. Environmental Protection Agency, 1983.

10. General Technology Report, Ammonia Removal by Steam Stripping for Nitrochem Inc.

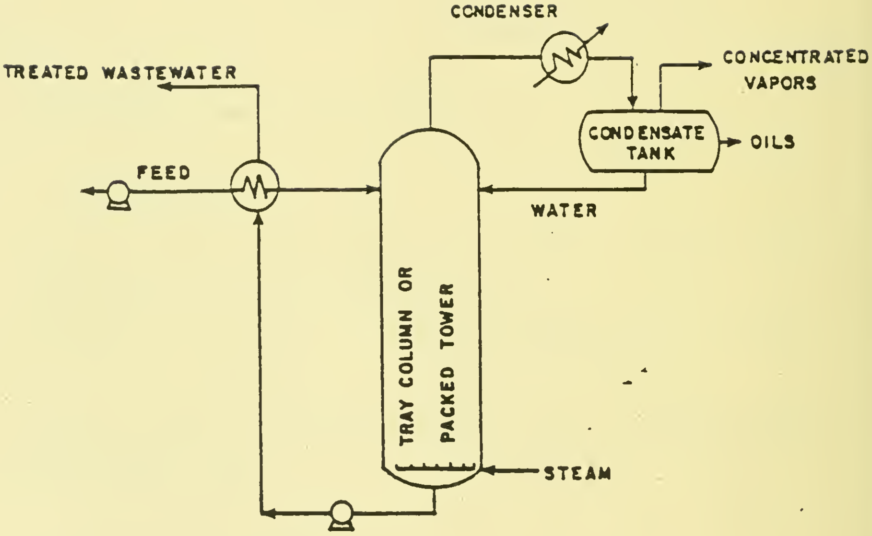
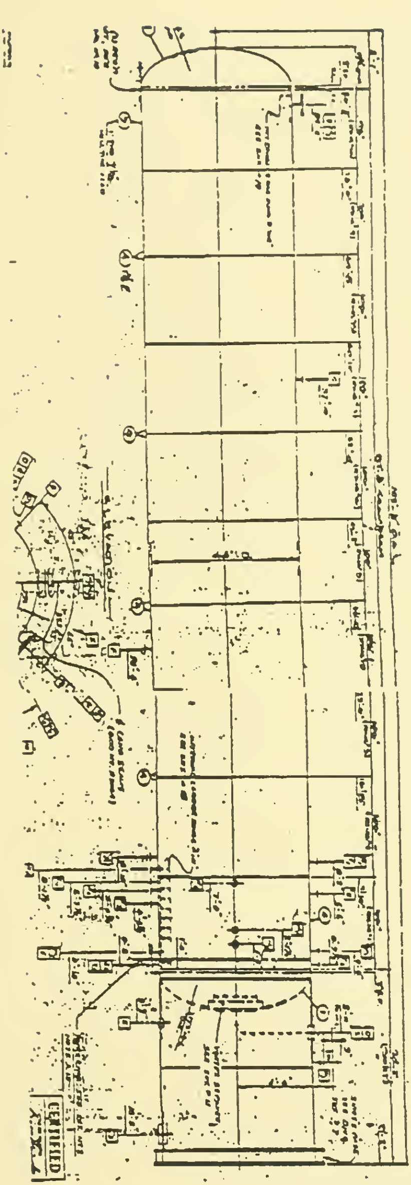


FIGURE A1
SCHEMATIC OF A TYPICAL STEAM STRIPPING PROCESS



sieve type trays

wall thickness
- top hd. .85 min. tk.
- bot hd. 1 1/8" min. th.

weight - 80,202 lbs.

FIGURE A2
SCHEMATIC FOR BRAUN STRIPPER

APPENDIX A

Reference List and Lists of Contacts

Appendix A
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Table A.1
List of Canadian Contacts Made In Search of BAT for the Ontario Inorganic Chemical Sector

Category	Name	Affiliation	Date	Comments
Abrasives Manufacturing	Richard Chambers Staff Engineer, Pollution Control (416) 295-4311	Norton Advanced Ceramics, Niagara Falls, Ontario	Aug. 1, 1991	Information on Norton's new parent firm in France was requested. Mr. Chambers indicated that the firm is not an abrasives manufacturer. He also provided information on why non-contact cooling water jackets are not technically feasible in abrasives plants.
Chemical Cost Information		Canada Colours Ltd.	Aug. 1991	Called to obtain treatment chemical costs.
		Dearborne Chemical Company Ltd.	Aug. 1991	Called to obtain treatment chemical costs.
Chlor-alkali Manufacturing	Oscar Zamora Plant Manager	PPG Chemicals Canada, Ltd.	July 1, 1991	This facility was recently converted to membrane cell technology. They are still operating their sulphide precipitation treatment for decontamination of equipment and a storage area. A site visit was scheduled for July 16, 1991.
	Alan Pemberton	Chemetics		Information collected by SAIC was unavailable.
	Eve Sharon (902) 755-1785	CANSO New Glascow, Nova Scotia	June, 1991	Information on the plant processes and wastewater management systems were requested.
	Harry Frank (604) 892-5274	Canadian Oxy Squeamish, B.C.	June, 1991	Information on the plant processes and wastewater management systems were requested.
General Search for "Sister" Plants	Foreign Desk Officers (613) 993-6435	External Affairs and International Trade, Ottawa, Ontario	June 3, 1991	Desk officers were contacted to see if they could facilitate overseas contacts with plants of interest. They agreed to provide contact names, addresses and phone numbers at each plant identified by CH2M HILL, through Canadian officers overseas.
	Dereck Yu Inorganic Chemical Sector Officer (414) 973-5159	Industry, Science and Technology Canada	June 3, 1991	This office was unable to assist in identifying or contacting "sister" plants or technologies overseas.
	Frank Johanson Europe, Middle East, South Asia Branch Senior Consultant (416) 325-6511	Ontario Ministry of Industry, Trade & Technology, Toronto, Ontario	May 31, 1991	This office was unable to assist in identifying or contacting "sister" plants or technologies overseas.
	Barry Briscoe (204) 983-4811	Environment Canada, Winnipeg Office	Apr. 4, 1991	Mr. Briscoe was asked to comment on plants with potential BAT in Manitoba.

Table A.1
List of Canadian Contacts Made In Search of BAT for the Ontario Inorganic Chemical Sector

Category	Name	Affiliation	Date	Comments
General Search for "Sister" Plants (cont'd)	Peter Paine Program Engineer	Chemical Industries Division, Industrial Programs Branch, Environment Canada, Ottawa, Ontario.	Apr. 18, 1991	Mr. Paine identified potential BAT plants based on information from all Regional Environment Canada offices in Canada. A letter was provided that summarized the list of plants, with contacts.
General Technology Information.	Paul S. Charles	Wallace & Tierman Canada Inc.	Sept. 1991	Mr. Charles provided cost and performance information on dechlorination systems.
	R. Standing Sales Manager	Dionex Systems Brantford, Ontario	Oct. 1991	Mr. Standing provided ion exchange system costs.
	A. Pizans	Laidlaw Environmental Systems	Oct. 1991	Mr. Pizans provided hazardous waste disposal cost information.
		A&A Liquid Waste Removal Company	Oct. 1991	Liquid industrial waste pick-up and disposal cost information was provided.
	Paul Boron	Calgon Canada	Oct. 1991	Cost and design information on GAC contactors was provided.
Explosives Manufacturing	Gord Jorgenson	ICI Explosives Division, North York	July 31, 1991	Mr. Jorgenson was contacted for information on the ICI explosives manufacturing facility in McMastervill, P.Q. The plant does not manufacture water gel explosives but does manufacture ANFO.
Nitrogen Fertilizer Manufacturing	Gordon Collis Plant Administrator (204) 729-2870	Simplot Canada, Brandon, Manitoba	June 7, 1991 July 3, 1991	Information of the wastewater management systems at the facility was provided by Mr. Collis. Based on this information, a site visit was carried out.
	Don McArthy Operations Supervisor (403) 885-4010	COMINCO Joffre Nitrogen Operation, Alberta	May 31, 1991	This plant only produces anhydrous ammonia. No process wastewater is discharged.
	Stu Bexton General Manager (403) 258-4600	COMINCO, Calgary, Alberta	May 31, 1991	Small, older plant that produces urea, anhydrous ammonia and ammonium nitrate solutions.
Plant Specific Technologies	Joshua Burru	Nitrochem Inc., Maitland, Ontario	Aug./Sept. 1991	Mr. Burru provided information on a steam stripping system currently being considered for Nitrochem.
	R. Molt, T. Tulimowski	ICI Nitrogen Products, Lambton Works, Ontario	Aug./Sept. 1991	Information on a steam stripping and surface condenser operation at ICI was provided.

Table A.1
List of Canadian Contacts Made In Search of BAT for the Ontario Inorganic Chemical Sector

Category	Name	Affiliation	Date	Comments
Plant Specific Technologies (cont'd)	L. Lucrw	General Chemical Canada Ltd., Amherstburg, Ontario	Dec. 1991	Heat exchange information on the barometric condensers at the plant was provided.
Sulphuric Acid Manufacturing	Dennis Smerchanski	Borden Chemicals, Winnipeg, Manitoba	May 31, 1991	This company was unwilling to release any information related to wastewater management.

Table A.2
List of U.S. Contacts Made In Search for BAT for the Ontario Inorganic Chemical Sector

Category	Name	Affiliation	Date	Comments
Abrasives Manufacturing	George Tasevski (716) 692-4550	Exolon-ESK, Buffalo, NY	Aug. 19, 1991	This plant gets its raw material from the Ontario plant. There is no furnacing operation, as they only crush, grind and classify materials. They have no discharge permit.
	Mark Rollins Corporate Health & Safety Director (508) 795-2584	Norton Company, Worcester, Mass.	Aug. 22, 1991 Aug. 29, 1991	Norton has one furnace operation in Alabama which is "sister" to Norton's Ontario plant. They use settling treatment, similar to the Ontario plant.
	Dean Venturine (716) 278-6763	Washington Mills, Niagara Falls, NY	Aug. 16. 1991	The Niagara Falls, New York plant has a smaller furnace operation, similar to the Washington Mills plant in Ontario. Treatment includes settling in a concrete basin, with no recycle back to process.
Aluminum Chloride Manufacturing	Jerry Vail Plant Manager (713) 476-4321	Witco Corporation, Argus Division, Pearsall Products, Laporte, TX	Aug. 29, 1991	Wastewater treatment at this plant includes continuous neutralization and clarification of effluents. Clarifier sludge is thickened and landfilled. "First flush" stormwater is also collected and treated.
	Dave Campbell (908) 859-2222	Witco Corporation	Aug. 29, 1991	pH adjustment, polymer addition and clarification are used to treat process effluents, primarily scrubber water, prior to discharge.
Carbon Black	William Fleming (404) 399-8725	Cabot Corp. Atlanta, GA	June 25, 1991 June 26, 1991	These calls were made to establish why zero-discharge could not be achieved at Ontario or U.S. Cabot plants. The water treatment plant at the Ontario plants was said to be the best demonstrated of all Cabot facilities. Only one plant in the U.S. does not discharge process water, and is located in Texas, where evaporation is used.
	Tom Adkins Corporate Environmental Engineer	Columbian Chemicals	June 4, 1991	He reported that none of the Columbian plants use wet air scrubbers. Also, wastewater management practised in Hamilton, Ontario represents most current technology compared to other Columbian plants in North America.
Carbon Graphite Manufacturing	David Mieskowski	Union Carbide UCAR, Cleveland, OH	June 25, 1991	Mr. Mieskowski provided comment on all UCAR plants in the U.S.

Table A.2
List of U.S. Contacts Made In Search for BAT for the Ontario Inorganic Chemical Sector

Category	Name	Affiliation	Date	Comments
Chlor-alkali Manufacturing	Chris Manley Environmental Manager (205) 389-2200	Occidental Chemical Co., Muscle Shoals, AL	July 25, 1991	This is the only mercury cell plant in the U.S. not using sulphide precipitation for mercury removal. They are treating with hydrazine to precipitate mercury as metal, and and then filter the effluent. The performance is comparable to sulphide precipitation.
	Art Duncan Plant Operations Specialist (202) 775-2790	The Chlorine Institute, Washington, DC	May 21, 1991	Mr. Duncan reported that 16 of 17 operating mercury cell plants in the U.S. use sulphide precipitation for wastewater treatment, and indicated the name of the Occidental Chemical facility in Muscle Shoals. The Institute do not provide names of contacts at member plants.
	(908) 225-4840	LCP Chemicals & Plastics, Inc., Edison, NJ	May 24, 1991	A contact at the LCP, Solvay, NY, facility was provided.
	Tim Van Domlen Manager of Environmental Affairs (315) 487-4700	LCP Chemicals, Inc., Solvay, NY	May 28, 1991 Aug. 1, 1991	This plant uses sulphide precipitation followed by a mercury-specific ion exchange resin system for treating ground water from an old mercury cell plant being decommissioned. Mr. Van Domlen provided design and operating information for the ion exchange system.
Hydrofluoric acid/Chloro-fluorocarbon Manufacturing	Jim Cooper Director of Pollution Control (201) 455-5040	Allied-Signal Corp., Engineered Materials Sector, Morristown, NJ	June 15, 1991	The corporate office was contacted to learn more about the U.S. operations and identify any "sister" plants to be visited.
	Alan Roy (804) 530-6155	Allied-Signal Corporation, Chesterfield, VA	July 2, 1991 July 12, 1991 July 16, 1991 July 22, 1991	Mr. Roy provided information on Allied plants in Baton Rouge and Geismar, and arranged site visits to these plants.
Explosives Manufacturing	Lynn Green Manager of Governmental Affairs (202) 429-9280	Institute of Makers of Explosives, Washington, D.C.	Apr. 23, 1991 May 8, 1991	Ms. Green was asked to identify a "sister" plant for ETI in the Ontario sector. Out of 29 member plants, only the ETI plant in Seneca was identified as producing similar products to the Ontario plant.
General Search for "Sister" Plants	Dr. Thomas Fielding	U.S. EPA Industrial Technology Division, Washington, D.C.	Mar. 21, 1991	Dr. Fielding was visited in person to discuss his experiences in developing the U.S. inorganic sector regulation, their implementation and changes to the regulation since implementation.

Table A.2
List of U.S. Contacts Made In Search for BAT for the Ontario Inorganic Chemical Sector

Category	Name	Affiliation	Date	Comments
Industrial Gas Manufacturing	Bob Bujalski (203) 794-2000	Union Carbide-Linde, Corporate Office, Danbury, CT	June 11, 1991	Mr. Bujalsiki was asked about BAT for wastewater pollution at their many gas plants in North America. He identified the elimination of chromate based water treatment chemicals, and the testing of ozone for water treatment as technology they are using. Oil and grease is also a concern at some plants. Gravity oil separation, and possible absorption pads for stormwater are used.
	Randy Fletcher (716) 879-2431	Union Carbide-Linde, NY	July 30, 1991 July 31, 1991 Aug. 1, 1991 Aug. 13, 1991	Mr. Fletcher provided an overview of wastewater management practices at the 65 Linde sites in the U.S. At some plants with specific problems, such as copper contamination, treatment is used. With the exception of ozone, which is still in the developmental stages, potential BAT for the Ontario plants was not identified.
Mercury Removal Technologies	David Dally Marketing Services Manager (609) 893-1100	Sybron Chemicals, Inc. Birmingham, NJ	Aug. 29, 1991	The company was called to obtain price and technical information on their mercury specific ion exchange resins, trade named IONAC.
Nitrogen Fertilizer Manufacturing	Karl T. Johnson (202) 675-8250	The Fertilizer Institute, Washington, D.C.	Apr. 15, 1991	Mr. Johnson was asked about nitrogen fertilizer facilities which were demonstrating advanced wastewater management technology in the U.S. He said that little had been done since the late 1970s when regulations were promulgated. Several names of plants and contacts of potential interest to the study were provided.
	George Haney (913) 843-7300	Farmland Industrial, Inc., Lawrence, Kansas	Apr. 16, 1991	A description of wastewater management technologies was provided. Methods include in-plant spill prevention, and aeration of equalization lagoons for spill control.
	Tom Carville (504) 473-8291	CF Chemicals, Inc., Donaldsonville, LA	Apr. 23, 1991	A description of wastewater management technologies was provided. Methods include collection of process wastewaters for production of urea ammonium nitrate solution, in-plant treatment and recycle or reuse, BMPs.
	Roy Dugan (904) 994-5511	Air Products, Pensacola, Florida	Apr. 18, 1991	A description of wastewater management technologies was provided. Methods include biological nitrogen removal in anaerobic and facultative lagoons, with a system HRT of 90-120 days.

Table A.2
List of U.S. Contacts Made In Search for BAT for the Ontario Inorganic Chemical Sector

Category	Name	Affiliation	Date	Comments
Nitrogen Removal Technologies	Irwin Higgins (615) 483-7424	Lake Industries, Inc., Oak Ridge, TN	July 31, 1991	In a former company he distributed ion exchange systems for removing ammonia from nitrogen fertilizer plant wastewater. Only one system is remaining in the U.S.
	George Atkinson (601) 746-4131	Mississippi Chemical Co., Mississippi	July 31, 1991	The plant had previously used an ion exchange system to remove 150-180 mg/L ammonia-N to about 50 mg/L. The backwashed ammonium-nitrate was sold as nitrogen solutions.
	Gary Steffens (913) 543-6571	Mineral-Right, Inc., Phillipsburg, Kansas	Sep. 2, 1991	The company has a developmental product for ammonia removal using natural zeolite. It is not commercially available, and will be intended for used in aquariums.
Phosphate Manufacturing and Gypsum Stack Closure	Dr. Jim Miller Corporate Environmental Director (504) 582-4239	Freeport-McMoran, New Orleans, LA	Sep. 4, 1991	Some information was provided on their gypsum stacks, and runoff management. Runoff from closed areas is subject to U.S. EPA effluent guideline and permit limitations.
	Carl Johnson Assistant Vice President Regulatory Programs (202) 675-8250	Fertilizer Institute, Washington, DC	Sep. 4, 1991	Mr. Johnson reported that gypsum stack closure are currently exempt from RCRA and a regulatory determination has not been made. He reported that closure was negotiated as part of final arrangements along with permit monitoring requirements.
	Dr. Thomas Fielding (202) 260-7156	U.S. EPA, Industrial Technology Division Washington, DC	Sep. 4, 1991 Sep. 26, 1991	Information was requested on U.S. EPA requirements for closure of phosphogypsum stacks. There are no specific requirements other than to stabilize the stacks in accordance with provisions in the state or federal discharge permit and treat any runoff prior to discharge.
Salt Removal Technologies	T. O'Neail	Resources Conservation Company, Bellevue, Washington	Nov. 12, 1991	Information was requested on costs and performance of brine concentrator systems.

Table A.3

List of Overseas Contacts Made in Search of BAT for the Ontario Inorganic Chemical Sector

Category	Name	Affiliation	Date	Comments
Abrasives Manufacturing	Herr Donauer 49-2208-69672	Huls AG (formerly Dyanmit Nobel), Luisdorf Niederkassel, Germany	Aug. 13, 1991	This plant is not a "sister" to the Ontario operations. Its wastewater management processes include a "tower biology" technology developed by Bayer AG for organics removal.
Chlor-alkali Manufacturing	Mr. J. Heerdink	Akzo Salt and Basic Chemicals Nederland bv	July 26, 1991	Mr. Heerdink sent a letter containing published information on the Imac TMR ion exchange process for mercury removal
Cyanamide Products Manufacturing	Mr. Weinzaepfel Manager for Water Treatment and Environment 33-1-4555-4430	Societe Chimique de la Grand Paroisse SA, France	Aug. 1991	After several calls and contacts with various people at the company and head office, they responded that they were unable to provide any information for the study.
General Search for BAT	Herr Tremel 49-2241-2320	Abwasser Technische Vereinigung (Wastewater Technical Association), Germany	Aug. 15, 1991	This organization assists its members in developing wastewater systems for specific industries and is similar to a trade association. Information on technologies for various industries and suppliers was obtained.
	Maximillian Gege Executive Director 49-40-810-101	B.A.U.M., Germany	Aug. 30, 1991	This organization is an environmental association but deals with 'global' issues like ozone layer, global warming, etc.
	Mr. Baeler 010-32-2-238-9711	Belgian Federation of Chemicals Industry	Sep. 9, 1991	Mr. Baeler explained the regulatory situation with respect to wastewater discharges from fertilizer industries in Belgium.
	Bernd Mehlhorn	Umweltbundesamt, Germany	July 17, 1991	In response to a letter request for information, this organization sent a list of inorganic chemical manufacturing plants in Germany, a paper on wastewater treatment procedures and the German minimum requirements for discharging of wastewater from the Chemical Industry.
	Hiroshi Uyama	Japan Technical Information Centre, Washington, D.C.		After a telephone conversation, a letter was written to Mr. Uyama asking for information on several plants identified from the SRI Directory. He was to forward the request to contacs in Japan. Several follow-up calls were made; however, no response was received.

Table A.3
List of Overseas Contacts Made in Search of BAT for the Ontario Inorganic Chemical Sector

Category	Name	Affiliation	Date	Comments
Hydrofluoric Acid Manufacturing	Doktor Heppel 49-6151-722-929	E. Merck, Germany	Aug. 31, 1991	This plant produces hydrofluoric acid as well as pharmaceutical and a variety of other chemicals on site. They have combined wastewater treatment.
	Herr. Hermey 49-0208-859-990	Norsk Hydro, Germany	Sep. 2, 1991	The hydrofluoric acid manufacturing process at this plant does not discharge any wastewater.
Nitrogen Fertilizer Manufacturing	Alain Mullier Site Manager 32-65-641917	Kemira, Belgium	Aug. 31, 1991	They were unable to provide any information to assist with the study.
	W. Van den Heuvel	BASF, Antwerp	Oct. 10, 1991	They provided limited information on the internal recycle/reuse processes to reduce the discharge of ammonia with wastewater.
Soda Ash (Solvay) Process		Chemische Fabrik Kalk GMBH, Germany	June 25, 1991	In response to a request for information on their plant, they sent a letter replying that they were unable to participate in the study.
	Mr. Degroot 32-71-449337	Solvay, Belgium	Aug. 19, 1991	Mr. Degroot was unable to provide information on plant or processes without the permission of the corporate office.
	Dr. Meuller 43-6133-5411211	Solvay Osterreich GmbH, Austria	Aug. 13, 1991	Response similar to above.
	Doktor Schneider 49-411-8572321	Deutche Solvay Werke, Germany	Aug. 29, 1991	Response similar to above.
	Dr. Kogelnig	Solvay, Head Office, Brussels, Belgium	Sep. 23, 1991	They provided limited information on effluents limits at three European plants.
	Mr. Heerdink	Akzo Salt & Basic Chemicals, Belgium		They only have one Solvay plant, and it discharges to the sea.

APPENDIX B

Key Words Used in Computerized Literature Search

Table B.1
Key Words Used in Computerized Literature Search

SET 1	Manufacturer* or industry or plant
SET 2	Water or wastewater or effluent*
SET 3	Inorganic (f)[1] chemical and SET 1 and SET 2
SET 4	Hydrofluoric and SET 1 and SET 2
SET 5	Hydrochloric and SET 1 and SET 2
SET 6	Chlorine and SET 1 and SET 2
SET 7	Chlorofluorcarbon or CFC and SET 1 and SET 2
SET 8	Carbon (f) black and SET 1 and SET 2
SET 9	Explosive* and SET 1 and SET 2
SET 10	Calcium (f) carbide and SET 1 and SET 2
SET 11	Abrasive* and SET 1 and SET 2
SET 12	(Fibre and glass) or (fibre (f) glass) or (insulation (f) fibre) and SET 1 and SET 2
SET 13	Fertilizer and SET 1 and SET 2
SET 14	(Soda (f) ash) and solvay and SET 1 and SET 2
SET 15	Chlor(f) alkali and mercury and SET 1 and SET 2
SET 16	Phosphate and SET 1 and SET 2
SET 17	Phosphogypsum and SET 1 and SET 2
SET 18	Cyanamide and SET 1 and SET 2
SET 19	Aluminum (f) chloride and SET 1 and SET 2
SET 20	Fluoride and SET 2
SET 21	Mercury and SET 2
SET 22	Chloride and SET 2
SET 23	Phosphate and SET 2
SET 24	Aluminum and SET 2
SET 25	Ammonia or nitrate and SET 2
SET 26	Organic and SET 2
SET 27	Inorganic and SET 2
SET 28	Metal* and SET 2
SET 29	(best (f) available (f) technology*) and SET 2
SET 30	(best (f) management (f) practices) and SET 2

Notes:

1. (f) - followed by.